UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
West Coast Region
501 West Ocean Boulevard, Suite 4200
LONG BEACH, CA 90802

Refer to NMFS No: WCRO-2024-02917

December 6, 2024

Mr. Karl Stock
Regional Director
Mid-Pacific Region
U.S. Bureau of Reclamation
2800 Cottage Way, MP-3700
Sacramento, California 95825-1898

Re: Endangered Species Act Section 7(a)(2) Programmatic Biological Opinion for the Reinitiation of Consultation on the Long-Term Operation of the Central Valley Project and State Water Project

Dear Mr. Stock:

Thank you for your November 9, 2023, transmittal of the biological assessment that follows your September 30, 2021 request for reinitiation of consultation with NOAA's National Marine Fisheries Service (NMFS) pursuant to section 7 of the Endangered Species Act of 1973 (ESA; 16 U.S.C. 1531 *et seq.*) for the Long-Term Operation of the Central Valley Project (CVP) and State Water Project (SWP).

This document transmits NMFS' final biological opinion (opinion) based on information provided in the U.S. Bureau of Reclamation's (Reclamation) final biological assessment and associated attachments and appendices. NMFS has evaluated the proposed action for this consultation as a "mixed programmatic" action as defined by 50 CFR 402.02 because it includes some action components for which no additional consultation will be necessary and others that are considered at a framework-level. The enclosed final opinion will be effective upon Reclamation's issuance of a Record of Decision pursuant to the National Environmental Policy Act and will supersede the NMFS 2019 Biological Opinion for the Reinitiation of Consultation on the Long-Term Operation of the CVP and SWP. The final opinion included in this document concludes that Reclamation's proposed action results in the following determinations for the listed species and designated critical habitats:

Species/Critical Habitat	Determination
Endangered Sacramento River (SR) winter-run Chinook salmon (*Oncorhynchus tshawytscha*)	No jeopardy
SR winter-run Chinook salmon designated critical habitat	No destruction/No adverse modification
Threatened Central Valley (CV) spring-run Chinook salmon (*O. tshawytscha*)	No jeopardy
CV spring-run Chinook salmon designated critical habitat	No destruction/No adverse modification
Threatened California Central Valley (CCV) steelhead (*O. mykiss*)	No jeopardy
CCV steelhead designated critical habitat	No destruction/No adverse modification
Threatened southern distinct population segment (sDPS) of North American green sturgeon (*Acipenser medirostris*)	No jeopardy
sDPS of North American green sturgeon designated critical habitat	No destruction/No adverse modification
Endangered Southern Resident killer whales (*Orcinus orca*)	No jeopardy
Southern Resident killer whale designated critical habitat	No destruction/No adverse modification

In addition, on October 31, 2024, Reclamation transmitted to NMFS an Essential Fish Habitat (EFH) assessment on the Long-Term Operation of the CVP and SWP (Proposed Action), and requested EFH consultation under the Magnuson-Stevens Fishery Conservation and Management Act, as amended (16 U.S.C. 1801 *et seq.*) for Pacific Coast Salmon (Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, fall-run Chinook salmon, and late fall-run Chinook salmon), Coastal Pelagic Species (Northern anchovy), and Pacific Coast Groundfish (starry flounder). The EFH consultation will be completed separately.

Please contact Cathy Marcinkevage, of my staff, at (916) 930-3600 if you have any questions concerning this consultation, or if you require additional information.

Sincerely,

Jennifer Quan
Regional Administrator

Enclosure

cc: Copy to file ARN: 151422-WCR2021-SA00122

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LIST OF ACRONYMS AND ABBREVIATIONS

Term	Definition
7DADM	7-Day Average of the Daily Maximum Temperature
ACID	Anderson-Cottonwood Irrigation District
ALE-22	Alternative Loss Equation
ALE-TT	Alternative Loss Equation Technical Team
ALPS-IP	Alternative Loss Pilot Study Implementation Plan
Alt2v1	Modeling scenario Alternative 2 version 1. Also referred to as Alt2woTUCPwoVA
Alt2v2	Modeling scenario Alternative 2 version 2. Also referred to as Alt2woTUCPDeltaVA
Alt2v3	Modeling scenario Alternative 2 version 3. Also referred to as Alt2woTUCPAllVA
Alt2woTUCPAllVA	Modeling scenario Alternative 2 with all Voluntary Agreements but without Temporary Urgency Change Petitions. Also referred to as Alt2v3
Alt2woTUCPDeltaVA	Modeling scenario Alternative 2 with Delta CVP and SWP Voluntary Agreements but without Temporary Urgency Change Petitions. Also referred to as Alt2v2
Alt2woTUCPwoVA	Modeling scenario Alternative 2 without Voluntary Agreements nor Temporary Urgency Change Petition modeling. Also referred to as Alt2v1
Alt2wTUCPwoVA	Modeling scenario Alternative 2 without Voluntary Agreements but with Temporary Urgency Change Petitions considered
AMP	Adaptive Management Program
AMSC	Adaptive Management Steering Committee
ANOVA	Analysis of Variance
ARI	American River Index
ARMFS	American River Minimum Flow Schedule
ASH	Area of Suitable Habitat
BA	Biological Assessment
BAFF	Bio-Acoustic Fish Fence
BND	Sacramento River at Bend Bridge CDEC gauge
CAMT	Collaborative Adaptive Management Team
CCF	Clifton Court Forebay
CCR	Sacramento River Above Clear Creek CDEC gauge
CCTT	Clear Creek Technical Team
CCV	California Central Valley

Term	Definition
CDEC	California Data Exchange Center
CDFG	California Department of Fish and Game (now known as the California Department of Fish and Wildlife)
CDFW	California Department of Fish and Wildlife
CESA	California Endangered Species Act
cfs	cubic feet per second
CM1	First SAIL conceptual model
CM2	Second SAIL conceptual model
CM3	Third SAIL conceptual model
CM6	Sixth SAIL conceptual model
CM7	Seventh SAIL conceptual model
COMPASS	NMFS Comprehensive Passage model
CRR	Cohort Replacement Rate
CSAMP	Collaborative Science and Adaptive Management Program
CV	Central Valley
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
CWR	Center for Whale Research
CWT	Coded Wire Tag
D-1641	The revised 2000 Water Right Decision 1641
dB	decibel
DCP	Delta Conveyance Project
DDT	Dichlorodiphenyltrichloroethane
Delta	Sacramento-San Joaquin Delta
DPM	Delta Passage Model
DPS	Distinct Population Segment
DQA	Data Quality Act
DRERIP	Delta Regional Ecosystem Restoration Implementation Plan
DRY	Drought Relief Year
DSM	Decision Support Model
DSM2	Delta Simulation Model 2
DWR	California Department of Water Resources
EC50	Half maximal effective concentration
EOA	End of April
EOS	End of September

Term	Definition
EPA	United States Environmental Protection Agency
ePTM	Enhanced Particle Tracking Model
ESA	Endangered Species Act
ESU	Evolutionarily Significant Unit
EXP3	Modeling scenario Exploratory 3, Obligated Releases Scenario
FERC	Federal Energy Regulatory Commission
FMP	Fishery Management Plan
FNU	Formazin Nephelometric Units
FRFH	Feather River Fish Hatchery
GCM	Global Climate Model
GSSMB	Georgiana Slough Salmonid Migratory Barrier
HEC	Hydrologic Engineering Center
HGMP	Hatchery Genetic Management Plan
HOL	Holland Cut Near Bethel Island CDEC gauge
Hz	hertz
IOS	Interactive Object-oriented Simulation
IPCC	Intergovernmental Panel on Climate Change
ISAB	Independent Scientific Advisory Board
ITP	Incidental Take Permit
JLF	Sacramento River at Jellys Ferry CDEC gauge
JPE	Juvenile Production Estimate
kHz	kilohertz
KWK	Sacramento River at Keswick CDEC gauge
LAD	Length-At-Date
LC50	Lethal Concentration 50
LOCA	Localized Constructed Analog
LSNFH	Livingston Stone National Fish Hatchery
LTO	Long-Term Operation
MAF	million acre-feet
MDE	Modeled Discretionary Effect
mg/L	milligrams per liter
MRR	Minimum Release Requirement
NAA	No Action Alternative
NEP	Non-essential Experimental Population
NEPA	National Environmental Policy Act

Term	Definition
NMFS	National Marine Fisheries Service
NOEC	No Observable Effect Concentration
NPDES	National Pollutant Discharge Elimination System
NRKW	Northern Resident killer whale
NWFSC	Northwest Fisheries Science Center
OBAN	Oncorhynchus Bayesian Analysis
OBI	Old River at Bacon Island CDEC gauge
OH4	Old River at Highway 4 CDEC gauge
OMR	Old and Middle Rivers
PAH	Polycyclic Aromatic Hydrocarbon
PBF	Physical or Biological Feature
PCB	Polychlorinated Biphenyl
PCE	Primary Constituent Element
PFMC	Pacific Fishery Management Council
PG&E	Pacific Gas & Electric Company
pHOS	Percent of hatchery fish naturally spawning
ppb	parts per billion
ppm	parts per million
ppt	parts per thousand
PSP	Puget Sound Partnership
PST	Pacific Salmon Treaty
psu	practical salinity unit
PTM	Particle Tracking Model
RCP	Representative Concentration Pathway
RDPA	Redd Dewatering Protective Adjustments
Reclamation	United States Department of the Interior, Bureau of Reclamation
ROC	Reinitiation of Consultation
ROD	Record of Decision
RPA	Reasonable and Prudent Alternative
RPN	Ripon CDEC gauge
SAC	Sacramento River Upstream of Highway 44 CDEC gage
SAIL	Salmon and Sturgeon Assessment of Indicators by Life Stage
SaMT	Salmonid Monitoring Team
sDPS	Southern Distinct Population Segment
SHOT	Shasta Operations Team

Term	Definition
SIT	Science Integration Team
Sites	Sites Reservoir Project
SJRRP	San Joaquin River Restoration Program
SMSCG	Suisun Marsh Salinity Control Gates
SR	Sacramento River
SRG	Sacramento River Group
SRI	Sacramento River Index
SRKW	Southern Resident killer whale
SRP	Stepped Release Plan
SRS	Sacramento River Settlement
SRSC	Sacramento River Settlement Contractor
SRSP	Sacramento River Science Partnership
SRTTG	Sacramento River Temperature Task Group
SSM	Smolt Survival Model
SSP	Shared Socioeconomic Pathways
SST	Salmonid Scoping Team
STARS	Survival, Travel Time, and Routing Simulation model
STWG	Salmon Technical Working Group
SWFSC	Southwest Fisheries Science Center
SWP	State Water Project
SWRCB	State Water Resources Control Board
SWT	Stanislaus Watershed Team
TAF	thousand acre-feet
TDM	Temperature-Dependent Mortality
TMP	Temperature Management Plan
TUCP	Temporary Urgency Change Petition
USACE	United States Army Corps of Engineers
USCG	United States Coast Guard
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
VA	Voluntary Agreement
VSP	Viable Salmonid Population
WCR	West Coast Region
WDFW	Washington Department of Fish and Wildlife

Term	Definition
WIIN	Water Infrastructure Improvements for the Nation
WOMT	Water Operations and Management Team
WRAP	Winter-Run Action Plan
WRLCM	Sacramento River Winter-Run Chinook Salmon Life Cycle Model
WRO	Water Rights Order
WUA	Weighted Usable Area
YCI	Year Class Index
µg/L	micrograms per liter
µPa	micropascal

Note: Throughout this document there are references cited as CDFG, which refers to the California Department of Fish and Game. This name was changed to the California Department of Fish and Wildlife (CDFW) on January 1, 2013. However, for consistency on publications, references prior to January 1, 2013 will remain cited as CDFG.

1. INTRODUCTION

This Introduction section provides information relevant to the other sections of this document and is incorporated by reference into the sections below.

1.1. Background

NOAA's National Marine Fisheries Service (NMFS) prepared the biological opinion (opinion) and incidental take statement portions of this document in accordance with section 7(b) of the Endangered Species Act (ESA) of 1973 (16 U.S.C. 1531 *et seq.*), as amended, and implementing regulations at 50 CFR part 402.

We completed pre-dissemination review of this document using standards for utility, integrity, and objectivity in compliance with applicable guidelines issued under the Data Quality Act (DQA; section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001, Public Law 106-554). The document will be available within 2 weeks at the NOAA Library Institutional Repository [https://repository.library.noaa.gov/welcome]. A complete record of this consultation is on file at the Sacramento NMFS Office.

The ESA establishes a national program for conserving threatened and endangered species of fish, wildlife, plants, and the habitat they depend on. As required by section 7(a)(2) of the ESA, each federal agency must ensure that its actions are not likely to jeopardize the continued existence of endangered or threatened species or to adversely modify or destroy their designated critical habitat. Per the requirements of the ESA, federal action agencies consult with NMFS.

Section 7(b)(3) of the ESA requires that, at the conclusion of consultation, NMFS' opinion states how the agency's actions would affect listed species and their critical habitats. If incidental take is reasonably certain to occur, section 7(b)(4) of the ESA requires NMFS to provide an incidental take statement that specifies the impact of such incidental taking and includes reasonable and prudent measures, if necessary or appropriate, and terms and conditions to implement the reasonable and prudent measures.

If NMFS determines that the action is likely to jeopardize ESA-listed species or destroy or adversely modify critical habitat, NMFS provides a Reasonable and Prudent Alternative (RPA) that allows the action to proceed in compliance with section 7(a)(2) of the ESA.

NMFS prepared the opinion and incidental take statement portions of this document in accordance with section 7(b) of the ESA of 1973 (16 U.S.C. 1531 *et seq.*), as amended, and implementing regulations at 50 CFR part 402. Updates to the regulations governing interagency consultation (50 CFR part 402) were effective on May 6, 2024 (89 FR 24268, April 5, 2024). We are applying the updated regulations to this consultation. The 2024 regulatory changes, like those from 2019, were intended to improve and clarify the consultation process, and, with one exception from 2024 (offsetting reasonable and prudent measures), were not intended to result in changes to existing practice in implementing section 7(a)(2) of the ESA (84 FR 44976, August 27, 2019, 89 FR 24268, April 5, 2024). We have considered the prior rules and affirm that the substantive analysis and conclusions articulated in this opinion and incidental take statement would not have been any different under the 2019 regulations or pre-2019 regulations.

This document represents NMFS' opinion on the effects of the proposed action described in Section 2 on the endangered Sacramento River (SR) winter-run Chinook salmon evolutionarily significant unit (ESU, *Oncorhynchus tshawytscha*), the threatened Central Valley (CV) spring-run Chinook salmon ESU (*O. tshawytscha*), the threatened California Central Valley (CCV) steelhead distinct population segment (DPS, *O. mykiss*), the threatened southern DPS (sDPS) of North American green sturgeon (*Acipenser medirostris*), and endangered Southern Resident DPS of killer whale (SRKW, *Orcinus orca*), and their designated critical habitats.

NMFS completed a biological opinion for the coordinated Long-Term Operation (LTO) of the Central Valley Project (CVP) and State Water Project (SWP) on October 21, 2019. The January 20, 2021, Executive Order 13990, entitled "Protecting Public Health and the Environment and Restoring Science to Tackle the Climate Crises," directed a review of the opinion. In a memorandum dated May 21, 2021, the U.S. Department of Interior, Bureau of Reclamation (Reclamation), NMFS, and the U.S. Fish and Wildlife Service (USFWS) determined that the review would be carried out through a process that was currently underway with the State of California to reconcile measures provided in the opinion with the State's March 31, 2021, Incidental Take Permit (ITP) for the LTO of the SWP. The agencies anticipated that this process could result in an agreement in principle to modify the plan for the LTO of the CVP and SWP, which could be subject to further compliance by the federal agencies consistent with applicable federal law, including likely reinitiation of consultation under the ESA. The topics that were addressed in the review of the opinion and the subject of reconciliation with the State of California include:

- Operation of Shasta Reservoir for Outflow and Cold Water Pool Management
- Sacramento-San Joaquin Delta (Delta) operations for fish migration, recruitment, and survival
- Incidental take
- Agency roles in decision making
- Adaptive Management
- Exploration of additional measures and actions that support fish species and reduce extinction risk

On September 30, 2021, Reclamation requested reinitiation of ESA section 7 formal consultation on the LTO of the CVP and the SWP, pursuant to 50 CFR § 402.16 of the federal ESA with the USFWS and NMFS. The purpose of the request to reinitiate consultation was based on anticipated modifications to the proposed action that may cause effects to listed species or designated critical habitats not analyzed in the USFWS and NMFS opinions on the LTO of the CVP and the SWP, dated October 21, 2019. On October 1, 2021, NMFS replied, indicating that they would provide technical assistance to develop and analyze a new proposed action and to utilize the best scientific and commercial information available. On June 30, 2023, Reclamation transmitted a qualitative Biological Assessment (BA), intended as an initial step to assist the USFWS and NMFS in preparing for formal consultation. On November 9, 2023, Reclamation transmitted a BA to support the September 30, 2021, reinitiation of consultation request. The 2023 BA describes each of the proposed action components by geographic location, including the watersheds of the Sacramento River, Clear Creek, American River, Stanislaus River, San Joaquin River, and CVP and SWP facilities in the Delta and Suisun Marsh and Bay. On June 27, 2024, NMFS received the information necessary to initiate ESA section 7 formal consultation. Throughout the consultation process, NMFS coordinated with Reclamation for clarification on

specific sections and modeling information. On October 31, 2024, NMFS received the revised and final proposed action. Hereafter, citations to Reclamation (2023-2024) will include: (1) Reclamation's November 2023 final BA, (2) all of the lines of evidence that NMFS received from Reclamation, and (3) Reclamation's final October 2024 proposed action.

The proposed action more effectively aligns Reclamation and the California Department of Water Resources (DWR) operations in the Delta, introduces a new operational framework for Shasta Reservoir operations that improves drought resilience for operations and fish conditions, and introduces changes to Clear Creek, Stanislaus River, and American River flows and temperature management. The consultation pathways considered for the proposed action components are listed in Table 1. NMFS evaluated the proposed action as a "mixed programmatic" action since it includes some framework-level actions that will be subject to subsequent project-level ESA section 7 consultation. For more details, refer to Section 3 Analytical Approach.

Table 1. Consultation pathways for different components of the proposed action.

Action Category	Consultation Approach	Rationale
Division-specific Water Operations ● Sacramento River ● Clear Creek ● American River ● Stanislaus River and East Side Division ● Sacramento-San Joaquin River Delta	Action-specific: Endangered Species Act (ESA) section 7 consultation that includes a quantified effects analysis and an incidental take statement.	The U.S. Bureau of Reclamation's (Reclamation) biological assessment includes a detailed proposed action and quantitative modeling and analyses that support an action-specific consultation approach, effects analysis, and an incidental take statement.
Spring Outflow - Early Implementation	Action-specific: ESA section 7 consultation that includes a quantified effects analysis and an incidental take statement.	The proposed action includes a 2-year commitment from Reclamation to support early implementation of enhanced spring outflow through export curtailments. This may be extended if Voluntary Agreements (VAs) have not been incorporated in the State Water Resources Control Board (SWRCB) has yet to incorporate VAs into the Bay-Delta Water Quality Control Plan (WQCP) but there is substantial progress being made to incorporate them. The proposed action includes an analysis for the Bay-Delta Division that analyzes approximately 2 years of spring outflow action (Delta VAs) and assumes no VAs after 2 years.

Action Category	Consultation Approach	Rationale
Spring Outflow - Post early implementation	Action-specific: ESA section 7 consultation that includes a quantified effects analysis and an incidental take statement. AND Framework Programmatic: for purposes of an incidental take statement, a federal action that approves a framework for the development of future action(s) that are authorized, funded, or carried out at a later time, and any take of a listed species would not occur unless and until those future action(s) are authorized, funded, or carried out and subject to further ESA section 7 consultation.	The proposed action proposes two potential post pre-adoption pathways: (1) Reclamation and the California Department of Water Resources (DWR) operate consistent with VAs if the SWRCB incorporates them into the WQCP and the VA parties execute VA agreements (Delta VAs or All VAs), OR (2) If the SWRCB does not incorporate VAs into the WCQP and VA parties do not execute agreements, Reclamation and DWR will operate as described in the proposed action but without export curtailments (Delta VAs).[1] AND The proposed action includes enough information to support the Framework Programmatic evaluation in this opinion that establishes a mechanism for a future tiered consultation on long-term actions that support VAs if the SWRCB incorporates Delta VAs or All VAs into the WQCP after 2 years and when VA parties execute agreements.
Sites and DCP	Framework Programmatic: ESA section 7 consultation that includes a qualitative effects analysis but no incidental take statement	Framework Programmatic approach for these projects establishes a mechanism for a future tiered consultation as described in Reclamation's proposed action.
Drought Toolkit	Mixed Programmatic	The Drought Toolkit contains a mix of Framework Programmatic actions that are not being authorized or exempted from take in this biological opinion; and programmatic actions with sufficient level of detail and certainty to be analyzed quantitatively and included in the incidental take statement.

[1] On October 15, 2024, Reclamation modified their commitment to continue export curtailments after 2 years if the SWRCB approves the VAs and the other parties are still in the process of executing the agreements. This is a minor adjustment, and we did not adjust our analysis to reflect a possible extension past year 2, although it is possible that the benefits of the action could continue for more than 2 years.

Action Category	Consultation Approach	Rationale
Winter-run Action Plan	Other Activities[2]	The Winter-run Action Plan would not have been developed "but for" the Shasta Framework in the proposed action, and not all actions in the Winter-run Action Plan are specifically proposed by Reclamation or actions over which Reclamation has discretion.
Monitoring	• Ongoing monitoring will be analyzed in the Environmental Baseline • Potential Future Changes to Monitoring will be included as Framework Programmatic actions	As described in Section 3.10 of the biological assessment (U.S. Bureau of Reclamation 2023-2024)
Adaptive Management and Special Studies	Mixed Programmatic	The Adaptive Management Program and Special Studies sections of the biological assessment contain a mix of Framework Programmatic actions that are not being authorized or exempted from take in this biological opinion; and programmatic actions with sufficient level of detail and certainty to be analyzed quantitatively and included in the incidental take statement.

1.2. Coordinated Operations Agreement

In November 1986, Reclamation and DWR signed the *Coordinated Operations Agreement*, which defines the rights and responsibilities of the CVP and SWP with respect to in-basin water needs and provides a mechanism to account for those rights and responsibilities. Congress, through Public Law 99-546, authorized and directed the Secretary of the Interior to execute and implement the *Coordinated Operations Agreement*. Under the *Coordinated Operations Agreement*, Reclamation and DWR agree to operate the CVP and SWP, respectively, under balanced conditions in a manner that meets Sacramento Valley and Delta needs while maintaining their respective water supplies, as identified in the *Coordinated Operations Agreement*. "Balanced conditions" are defined as periods when the CVP and SWP agree that releases from upstream reservoirs, plus unregulated flow, approximately equal the water supply needed to meet Sacramento Valley in-basin uses and CVP and SWP exports. The *Coordinated Operations Agreement* is the federal nexus for ESA section 7 consultation on operations of the SWP. In this LTO consultation, DWR is considered an applicant.

[2] Effects of the action include consequences of "other activities" that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur.

In 2018, Reclamation and DWR modified four key elements of the *Coordinated Operations Agreement* to address changes since it was originally signed: (1) in-basin uses; (2) export restrictions; (3) CVP use of Banks Pumping Plant up to 195,000 acre-feet per year; and (4) the periodic review. Details are provided in NMFS' 2019 Biological Opinion for the Reinitiation of Consultation on the Long-Term Operation of the Central Valley Project and State Water Project (LTO BA, U.S. Bureau of Reclamation 2019b). The *Coordinated Operations Agreement* sharing percentages for meeting Sacramento Valley in-basin uses now vary from 80 percent responsibility of the United States and 20 percent responsibility of the State of California in wet year types to 60 percent responsibility of the United States and 40 percent responsibility of the State of California in critical year types. In a dry or critical year following two dry or critical years, Reclamation and DWR will meet to discuss additional changes to the percentage sharing of responsibility to meet in-basin use. When exports are constrained and the Delta is in balanced conditions, Reclamation may pump up to 65 percent of the allowable total exports with DWR pumping the remaining capacity. In excess conditions, these percentages change to 60 percent United States and 40 percent State of California.

1.3. Key Consultation Considerations

Key considerations that provide context for this consultation include programs that are outside the scope of this consultation, such as CVP operations in the Trinity River, operation of Oroville Dam, the non-essential experimental population (NEP) of CV spring-run Chinook salmon in the San Joaquin River Restoration Program (SJRRP) area, and non-discretionary deliveries to water contractors. Final comments and recommendations received through peer review and Water Infrastructure Improvements for the Nation (WIIN) Act review were considered in the development of the final opinion. We summarize these items as context for this consultation below.

1.3.1. Trinity River Division

Although the Trinity River Division is part of the CVP, actions in the Trinity River portion of the Trinity River Division were identified as having previously undergone ESA consultation with NMFS in 2000 (National Marine Fisheries Service 2000). Future Trinity Reservoir operations that affect listed species in the Trinity River are expected to be addressed in a separate consultation, anticipated to occur in early 2025. Therefore, NMFS did not analyze any aspects of CVP operation on the Trinity and Klamath rivers, or their associated ESA-listed species (i.e., Pacific eulachon, Southern Oregon/Northern California Coast coho salmon) and designated critical habitats, as part of the proposed action in this consultation. NMFS also did not analyze production of the currently-unlisted Upper Klamath-Trinity River Chinook salmon, as it pertains to Chinook salmon availability as prey for SRKWs. Reclamation and NMFS will continue to coordinate on the separate Trinity consultation.

The remaining proposed action components of the Trinity River Division included in this opinion are associated with transbasin diversions into Whiskeytown Reservoir. Effects due to operations at Whiskeytown Reservoir, as well as Spring Creek diversions into Keswick Dam, are analyzed in this opinion.

1.3.2. Linkage to the Operation of Oroville Dam

The Oroville Complex (Oroville Dam and related facilities, including the Feather River Fish Hatchery [FRFH]) is part of the SWP. DWR has been operating the Oroville Complex under a Federal Energy Regulatory Commission (FERC) license and is currently undergoing a relicensing process (FERC Project No. 2100-134). On December 5, 2016, NMFS completed the ESA section 7 consultation and issued a biological opinion to FERC regarding the effects of relicensing the Oroville Complex for 50 years. Since the Oroville Complex and associated operations have already undergone ESA section 7 consultation, it is not included as part of the proposed action of this consultation.

1.3.3. Central Valley Spring-Run Chinook Salmon in the San Joaquin River

The CV spring-run Chinook salmon listed ESU boundary is currently delineated as all naturally spawned CV spring-run Chinook salmon originating from the Sacramento River and its tributaries downstream of barrier dams (70 FR 37160 2005, June 28, 2005). The listed ESU also includes CV spring-run Chinook salmon from the FRFH CV spring-run Chinook salmon program. The listed ESU boundary does not include the San Joaquin River or its tributaries because CV spring-run Chinook salmon were considered extirpated from the basin at the time of listing. The historical CV spring-run Chinook salmon ESU and its population groups (i.e., Diversity Groups) are delineated on the basis of geography as defined by mountain ranges (e.g., Northwestern, Basalt and Porous Lava, Northern Sierra, and Southern Sierra; Lindley et al. 2004).

In 2013, NMFS designated an NEP of CV spring-run Chinook salmon for reintroduction into the SJRRP Area pursuant to ESA section 10(j) (78 FR 79622, December 31, 2013). This designation allows for the reintroduction of CV spring-run Chinook salmon outside their current range as an NEP given that the NEP is geographically separate from the ESU-listed population of the same Chinook salmon run and, if lost, will not significantly impact the status of that species. Therefore, NMFS does not consider fish within the SJRRP Area in this opinion, as effects of the proposed action on individuals from this experimental population will not impact the status of the ESU. In addition, ESA section 4(d) provides protective regulations including ESA section 9 take exceptions for activities performed during otherwise lawful activities within the experimental population area. Any activities that result in direct intentional take, harm, or activities that are illegal in nature are still subject to ESA section 9 provisions. The ESA section 10(j) designation has allowed the SJRRP to implement reintroduction efforts in the SJRRP Area, and helps to ensure that NEP CV spring-run Chinook salmon do not result in more than de minimis water supply reductions, additional storage releases, or bypass flows on unwilling third parties, as described in the 2006 SJRRP Settlement.

In the San Joaquin river basin, outside of the SJRRP Area, there are no ongoing monitoring programs designed to target or detect CV spring-run Chinook salmon within the San Joaquin River or its tributaries. Therefore, all data and information collected over the past years were opportunistically collected during ongoing monitoring for CV fall-run Chinook salmon, which have a different run timing at the adult and juvenile life stages. Despite the lack of monitoring, CV spring-run Chinook salmon have been observed in the Tuolumne and Stanislaus rivers of the San Joaquin Basin in the last decade (Franks 2014). It is possible that the small CV spring-run Chinook salmon population described in Franks (2014) was bolstered in part by CV spring-run Chinook salmon from the FRFH (https://www.rmpc.org/). Detections of ESA-listed fish from the

FRFH have been observed in the San Joaquin River tributaries since 2002. Since 2016, observations of ESA-listed fish from the FRFH migrating into the San Joaquin River tributaries have not been recorded. However, this is likely an artifact of the aforementioned monitoring programs that are directed at sampling of CV fall-run Chinook salmon rather than targeting CV spring-run Chinook salmon presence.

More recently, juvenile and adult fin clips from Chinook salmon collected in 2021–2022 in the Stanislaus, Tuolumne, and Merced rivers were genetically analyzed by the Southwest Fisheries Science Center (SWFSC). The results report by Clemento and Garza (2023) concluded that individuals with at least some CV spring-run Chinook salmon ancestry were identified in all three rivers. The confirmed presence of CV spring-run Chinook salmon homozygote and spring/fall-run heterozygote juveniles confirms that adults with CV spring-run Chinook salmon ancestry successfully spawned in these rivers and strongly suggests that CV spring-run Chinook salmon were the parents of some of these individuals (Clemento and Garza 2023). As such, this new research contributes to a growing understanding that suggests passive reestablishment of CV spring-run Chinook salmon throughout the San Joaquin River basin (Gutierrez et al. 2024).

1.3.4. Non-Discretionary Deliveries

The proposed action includes delivery of non-discretionary quantities of water to any contractor entitled to such deliveries, and NMFS' effects analyses for the delivery of non-discretionary quantities to any contractor is considered in the opinion and incidental take statement. Although Reclamation has limited discretion to modify such quantities of water, it retains discretion with respect to operational decision-making as how to meet its obligations to such contractors, including, for example, the Sacramento River Settlement (SRS) Contractors (SRSCs), as well as other non-discretionary contractors, legal obligations, and project purposes.

1.3.5. Sacramento River Settlement Contractors Resolution

The SRSCs approved a resolution in 2019 regarding salmon recovery projects in the Sacramento River watershed, actions related to Shasta Reservoir annual operations, and engagement in the ongoing collaborative Sacramento River Science Partnership effort. The SRSCs, a California nonprofit mutual benefit corporation, consists of individuals and entities that individually hold settlement agreements (the SRS Contracts) with Reclamation. The SRSCs consist of 31 members with an annual water supply of 1,974,324 acre-feet. Reclamation operates Shasta Dam and Keswick Dam as part of the CVP and in accordance with the terms of the SRS Contracts.

The SRSCs resolution includes three key actions that were analyzed in the NMFS 2019 LTO biological opinion:

1. The SRSCs will meet and confer with Reclamation, NMFS, and other appropriate agencies to determine if there is any role for the SRSCs in connection with Reclamation's operational decision-making for Shasta Reservoir. This determination will include consideration of what actions are feasible, consistent with the terms and conditions of the SRS Contracts and would also effectuate the desired outcome.

2. The SRSCs will continue to participate in, and act as project champions for future Sacramento Valley Salmon Recovery Program projects, subject to the availability of funding, regulatory approvals, acceptable regulatory assurances, and full performance of the SRS Contracts.

3. The SRSCs will continue their active engagement and leadership in the ongoing collaborative Sacramento River Science Partnership effort.

1.3.6. Peer Review of the Draft Biological Opinion

NMFS completed a peer review of its draft opinion through a contract with Anchor QEA. Three reviewers, Robert Bilby (retired, Washington Governor's Salmon Recovery Office), Dr. Nann Fangue (Professor of Physiological Ecology, University of California, Davis), and Dr. Desirée Tullos (Professional Engineer, Professor, Biological and Ecological Engineering, Oregon State University), were selected as reviewers based on availability, knowledge, and experience. The panel primarily reviewed the effects of the action and integration and synthesis sections of the draft opinion for all ESA-listed species and their critical habitats. The reviewers also received relevant background information and supplemental materials, such as sections of Reclamation's BA and other draft sections of the opinion, to consider in their reviews. NMFS participated in two facilitated question and answer meetings and was otherwise available throughout the review period to respond to questions or address clarification needs.

On September 10, 2024, the peer reviewers issued their individual reports and findings to Anchor QEA and NMFS. Each of the peer review reports had constructive recommendations for the development of a more scientifically robust final opinion. In general, all of the peer reviewers and their reports acknowledged the incredibly complex proposed action, and that NMFS consistently applied the best available information in its development of the draft opinion.

This final opinion, and its supporting administrative record, considered and/or incorporated all of the substantive recommendations from the peer review, as appropriate.

1.3.7. Water Infrastructure Improvements for the Nation Act

Section 4004 of the WIIN Act of 2016 requires the Secretary of Commerce to ensure "that any public water agency that contracts for the delivery of water from the Central Valley Project or the State Water Project that so requests shall […] receive a copy of any draft biological opinion and have the opportunity to review that document and provide comment to the consulting agency through the action agency, which comments will be afforded due consideration during the consultation."

NMFS held three WIIN Act coordination meetings with California Public Water Agencies and other interested parties and provided opportunities to review the draft opinion and incidental take statement between April and October, 2024. This final opinion, and its supporting administrative record, considered and/or incorporated all of the substantive comments or recommendations from the WIIN Act review and peer review, as appropriate.

1.4. Consultation History

Reclamation has consulted with NMFS on CVP and SWP operations as species were listed and critical habitat designated since the early 1990s. The last consultation on CVP and SWP operations was completed on October 21, 2019 (National Marine Fisheries Service 2019b), with a February 18, 2020, Record of Decision (ROD, U.S. Bureau of Reclamation 2020). Table 2 provides the history of the current consultation.

Table 2. Consultation history.

Date	Issuer	Document	Subject/Species	Determinations
09.30.2021	Bureau of Reclamation	Requested reinitiation of consultation	Anticipated modifications to the Proposed Action that may cause effects to listed species or designated critical habitats [SR winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, sDPS green sturgeon, and SRKW] not analyzed in the National Marine Fisheries Service (NMFS) Biological Opinions, dated October 21, 2019.	
03.30.2023	Bureau of Reclamation	Qualitative Biological Assessment	SR winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, sDPS green sturgeon, SRKW, and their designated critical habitats	Likely to adversely affect SR winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, sDPS green sturgeon. Not likely to adversely affect SRKW To be determined for SR winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, sDPS green sturgeon, and SRKW critical habitat
11.09.2023	Bureau of Reclamation	Quantitative Biological Assessment (and appendices)	SR winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, sDPS green sturgeon, SRKW, and their designated critical habitats	Likely to adversely affect SR winter-run Chinook salmon and their critical habitat, CV spring-run Chinook salmon and their critical habitat, CCV steelhead and their critical habitat, and sDPS green sturgeon. Not likely to adversely affect sDPS green sturgeon critical habitat, SRKW and their critical habitat

Consultation History Continued: November 2023 Reclamation-Issued Qualitative Biological Assessment and Appendices		
Date Received	**Document**	**Subject/Species**
11.09.2023	Appendix A- Description of Facilities	Detailed description of location, authorization, operational specifications, water and power contracts, and other pertinent information for facilities of CVP and SWP.
11.09.2023	Appendix B-Water Operations and Ecosystem Analyses	Description of CVP and SWP operations to capture broad trends and patterns of hydrologic alteration.
11.09.2023	Appendix C - Species Spatial and Temporal Domains	Description of the presence of listed species by life stage and geographic region to inform species exposure.
11.09.2023	Appendix D - Seasonal Operations Deconstruction	Seasonal operations deconstruction appendix analyzes potential stressors on aquatic species and their critical habitats from CVP and SWP operations.
11.09.2023	Appendix E - Exploratory Modeling	Exploratory modeling identified to support the analytical foundation for understanding operational constraints and opportunities for the proposed action as well as potential systemwide capabilities and impacts from related processes.
11.09.2023	Appendix F - Attachment F - SummerFallX2 OMR Maunder and Deriso	Delta smelt life cycle model (Maunder and Deriso 2011) updated and generalized to evaluate OMR management effects on Delta smelt.
11.09.2023	Appendix F - Attachment X - CVPIA Winter-Run and Spring-Run LCMs	Description and model overview of the CVPIA SIT decision support models for SR winter-run and CV spring-run Chinook salmon, describing model assumptions and limitations.
11.09.2023	Attachment - LCM Recalibration - CVPIA SIT LCM	Description of the rationale for recalibration of the CVPIA SIT life cycle model to include upper Sacramento River rearing survival changes and correct size class-specific survival terms.
11.09.2023	Attachment - CalSim II to CalSim 3 Conversion - CVPIA SIT LCM	Summary of the conversions from CalSim II to CalSim 3 for all flow inputs to the v2019 SIT DSMs, updating model inputs to reflect CalSim 3 modeling scenarios.

Consultation History Continued: November 2023 Reclamation-Issued Qualitative Biological Assessment and Appendices		
Date Received	**Document**	**Subject/Species**
11.09.2023	Appendix F - Attachment X - CVPIA Spring-Run LCM	Description and results of the CVPIA SIT CV spring-run Chinook salmon decision support model.
11.09.2023	Appendix F - Attachment X - CVPIA Winter-Run LCM	Description and results of the CVPIA SIT SR winter-run Chinook salmon decision support model.
11.09.2023	Appendix F - Attachment X - LCA Delta Smelt LCME	Description and results for the Delta smelt life cycle and entrainment model.
11.09.2023	Appendix G - Facility and Water Operations Deconstruction	The facility and water operations deconstruction appendix analyzes potential stressors and effects associated with Reclamation and DWR facility maintenance and water supply added to the seasonal operations deconstruction described in Appendix D.
11.09.2023	Appendix H - Conservation Measures Deconstruction	The conservation measure deconstruction appendix analyzes actions to minimize or compensate for project effects or to benefit or promote the recovery of listed species.
11.09.2023	Appendix I - OMR	The OMR appendix analyzes the management of exports affecting Old and Middle River flows to reduce entrainment stressors on listed species.
11.09.2023	Appendix I - Attachment I.1 - Negative Binomial Model	Historical salvage data analyzed using the negative binomial regression to evaluate potential changes to the number of LAD species salvaged at the CVP and SWP pumping facilities.
11.09.2023	Appendix I - Attachment I.2 - OMR Salvage-Density Model Loss	The salvage-density model of entrainment into the south Delta facilities provides a quantitative analysis of salvage as a function of flow based on historical data.
11.09.2023	Appendix I - Attachment X - Delta Export OMR Zone of Influence Analysis	The zone of influence analysis evaluates the spatial extent of hydrologic alteration considering changes to velocity and changes to the distributions of hourly average velocity as a result of exports under varying OMR flow conditions.

Consultation History Continued: November 2023 Reclamation-Issued Qualitative Biological Assessment and Appendices		
Date Received	**Document**	**Subject/Species**
11.09.2023	Appendix I - Attachment X - OMR LFS Salvage OMR Relationship	The longfin smelt salvage OMR relationship models salvage at South Delta facilities as a function of flow based on historical salvage data.
11.09.2023	Appendix I - Attachment X - OMR STARS Model	The STARS model (Survival, Travel time, and Routing Simulation) is an individual-based simulation that predicts survival, travel time, and entrainment of juvenile salmonids migrating through the Delta.
11.09.2023	Appendix I - Attachment X - OMR Volumetric Influence Analysis	Volumetric influence analysis, estimates the fraction of Delta inflow that is diverted by the CVP and SWP export facilities, to identify the range of potential hydrodynamic influence on the environment.
11.09.2023	Appendix J - Spring Delta Outflow	The Spring Delta Outflow report, used to evaluate spring pulses and Delta outflow, integrates the effects of runoff, storage, releases, and diversions in the spring months, when native and other fish are at their most sensitive life stages.
11.09.2023	Appendix J - Attachment J - SpringDeltaOutflow LFS Outflow	The potential effect of operations on longfin smelt abundance is evaluated through the development of a statistical modeling, relating the longfin smelt Fall Midwater Trawl (FMWT) abundance index to Delta outflow; FMWT abundance index (T-2); and ecological regime.
11.09.2023	Appendix J - Attachment J - Sturgeon YCI vs Outflow	Sturgeon year-class strength (YCI) analysis assesses potential effects of the proposed project and alternatives on white or green sturgeon YCI using a correlative relationship with Delta outflow.
11.09.2023	Appendix J - Attachment J - Zooplankton-Delta Outflow Analysis	Zooplankton analysis examining the relationship between Delta outflow with Delta smelt and longfin smelt zooplankton prey density (catch per cubic meter) in the low salinity zone.

Consultation History Continued: November 2023 Reclamation-Issued Qualitative Biological Assessment and Appendices		
Date Received	**Document**	**Subject/Species**
11.09.2023	Appendix K - Summer and Fall X2	Summer and Fall X2 report evaluates the action as to the ability to increase the spatial overlap of key Delta smelt habitat attributes by moving habitat westward via releases from reservoirs, limiting exports, and by routing of freshwater flows for habitat connectivity and food web productivity.
11.09.2023	Appendix L - Shasta CWP	This appendix analyzes alternatives for the management of Shasta Reservoir for water temperatures downstream of Keswick Dam.
11.09.2023	Appendix L - Attachment L - CWP Storage and Coldwater Pool Exceedance Analysis	NEPA alternatives proposed for the long-term operations of the CVP and SWP have different types of storage and cold water pool criteria. CALSIM 3 results from NEPA alternatives were used to measure the frequency by which different thresholds are met by each of the alternatives. During development of these criteria (which are surrogates related to SR winter-run Chinook salmon biological objectives), several alternatives (Alternative 2 and Alternative 4) have differing storage and cold water pool criteria.
11.09.2023	Appendix L - Attachment L - Sacramento River Water Temperature Analysis	This analysis enumerates the frequency at which mean monthly HEC-5Q simulated water temperatures exceed water temperature index values or occur outside index ranges for multiple fish species in the Sacramento River upstream of the Delta.
11.09.2023	Appendix L - Attachment X - Egg-to-fry Survival and TDM	Models Martin et al. (2017) and Anderson et al. (2022) were used to predict egg-to-fry survival for SR winter-run Chinook salmon as a function of temperature-dependent egg mortality, background mortality, and density-dependent mortality.
11.09.2023	Appendix M - Folsom Coldwater Pool	Folsom Reservoir flow and temperature management address the tradeoffs for minimum releases and the use of available cold water pool in Folsom Reservoir for water supply, power production, and steelhead and fall-run Chinook salmon in the American River.

Consultation History Continued: November 2023 Reclamation-Issued Qualitative Biological Assessment and Appendices		
Date Received	**Document**	**Subject/Species**
11.09.2023	Appendix M - Attachment M - American River Redd Dewatering Analysis	The redd dewatering analyses are based on the maximum reduction in flow from the initial flow, or spawning flow, that occurs over the duration of an egg cohort. The analysis uses CALSIM 3 data, which have a monthly time-step, for the redd dewatering analyses. It assumes a new egg cohort begins each month of the spawning period. Results of the analysis are expressed as the percentage of redds dewatered.
11.09.2023	Appendix M - Attachment M - American River Water Temperature Analysis	This analysis enumerates the frequency at which mean monthly HEC-5Q simulated water temperatures exceed water temperature index values or occur outside index ranges for multiple fish species in the American River.
11.09.2023	Appendix M - Attachment M - American River Weighted Usable Area Analysis	Weighted usable area (WUA) analysis is a method for estimating the availability of suitable habitat in rivers, streams, and floodplains under different flow conditions. WUA curves showing suitable habitat availability versus flow are generated from the simulations. These curves facilitate evaluating how different flow regimes affect spawning and rearing habitat of important fish species. For this analysis, spawning WUA was estimated for fall-run Chinook salmon and California Central Valley steelhead in the American River.
11.09.2023	Appendix N - Stanislaus SRP	The New Melones Stepped Release Plan addresses the volume of instream flows that can occur over a multi-year hydrology without affecting reservoir levels to the extent of depleting the water pool to cause the release of warm water.
11.09.2023	Appendix N - Attachment N - Stanislaus River Water Temperature Analysis	This analysis enumerates the frequency at which mean monthly HEC-5Q simulated water temperatures exceed water temperature index values or occur outside index ranges for multiple fish species in the Stanislaus River. Water temperature was simulated in HEC-5Q for water years 1922 through 2020 for the Stanislaus River. Outputs from HEC-5Q were used as inputs to the analysis.

Consultation History Continued: November 2023 Reclamation-Issued Qualitative Biological Assessment and Appendices		
Date Received	**Document**	**Subject/Species**
11.09.2023	Appendix O - Tributary Habitat	Tributary habitat restoration appendix to the Public Draft EIS analyses addresses spawning and rearing habitat actions for the Sacramento River, American River, Stanislaus River, Clear Creek, and San Joaquin River. Project activities primarily include side channel and floodplain creation, expansion, and grading, spawning gravel and large cobble additions, and woody material additions.
11.09.2023	Appendix O - Attachment O - CWP Clear Creek WUA Analysis	For this analysis, spawning and rearing WUA were estimated for CV spring-run and fall-run Chinook salmon and California Central Valley steelhead in Clear Creek, Shasta County. Spawning and rearing WUA were estimated for the baseline scenarios and management alternatives from CalSim 3 flow data for each month of the 100-year period of record. The WUA analyses are based on a series of U.S. Fish Wildlife (USFWS) field studies conducted from 2004 through 2009.
11.09.2023	Appendix O - Attachment X - SIT LCM Habitat Estimates	Estimates of suitable habitat for Chinook salmon life stages, including spawning adults and rearing juveniles, that vary as a function of flow are estimated in this analysis using two methods: 1) weighted usable area (WUA) based on hydraulic modeling and habitat suitability curves and 2) the combination of hydraulic modeling and minimum habitat quality thresholds.
11.09.2023	Appendix O - Attachment XX - Sacramento River WUA Analysis	For this analysis, spawning and rearing WUA was estimated for SR winter-run, CV spring-run, fall-run, and late fall–run Chinook salmon and California Central Valley steelhead in the Sacramento River. Spawning and rearing WUA were estimated for the BA and EIS modeled scenarios from CalSim 3 flow data for each month of the 93-year period of record.
11.29.2023	LTO Appendix F Modeling (Main Report and Appendices)	CalSim 3 modeling, providing hydrological planning results that identify monthly average flows for the entire SWP and CVP system based on a 100-year record (1922–2021).

December 2023 Reclamation-Issued Appendices		
Date	**Document**	**Subject/Species**
12.06.2023	NBA Sediment and Aquatic Weed Removal Operating Procedures	SOP for sediment and aquatic weed removal at the North Bay Aqueduct used to identify potential effects of this action component.
12.06.2023	SDFPF Operations Manual	Operation manual of the South Delta (Skinner) Fish Protection Facility used to identify potential effects of this action component.
12.06.2023	TFCF Fish Handling Operations Manual and CDFW (2013) Salmon loss estimation	Operation manual and salmon loss equation for the Tracy Fish Collection Facility used to identify potential effects of this action component.
12.06.2023	Adaptive management plan and associated appendices	CVP and SWP LTO adaptive management plan used to identify approaches to addressing project uncertainty and potential adaptation.
12.06.2023	CCFB Weed Management Operating Procedures	Management operating procedures for Clifton Court Forebay weed control, used to identify potential effects of this action component.
12.06.2023	Drought Toolkit (vers. December 2023)	Current version of the interagency drought toolkit of drought response actions, used to identify potential effects of project-related drought response.
12.18.2023	Appendix J. Flow Threshold Salmon Survival	Flow/survival analysis utilizing threshold flows in the mainstem Sacramento River to inform changes in juvenile salmonid survival.
12.18.2023	Tidal Habitat Restoration Admin Process	Administrative procedures document describing the collaborative forum approach to tidal habitat restoration, used to provide certainty and clarity of tidal restoration components of the proposed action.

January 2024 Reclamation-Issued Appendices		
Date	**Document**	**Subject/Species**
01.05.2024	Appendix F. LCA IOS	The Interactive Object-oriented Simulation (IOS) Model for SR winter-run Chinook salmon used to inform effects of the action on multiple life-stages of the species.
01.05.2024	Appendix I. OMR Delta Passage Model	The Old and Middle River Delta Passage Model provides through-Delta survival estimates of Chinook salmon smolts used to estimate effects of Delta operations.
01.05.2024	Appendix I. OMR CWT Salvage Model	The Old and Middle River Coded Wire Tag Salvage Model provides estimates of hatchery-reared Chinook salmon salvage used to estimate effects of Delta operations.
01.05.2024	Appendix J. XT Model	The XT model (Anderson et al. 2005), considers the trade-off between the distance (X) a fish travels and the time spent (T) for a fish in a reach when calculating survival effects of the proposed action.
01.05.2024	Appendix L. WR Chinook salmon juvenile production index model	The Juvenile Production Index Model using flow during incubation and emergence and number of spawning females to estimate annual productivity related to the effects of the proposed action.
01.05.2024	Appendix L. CWP Juvenile Stranding Analysis	Juvenile stranding and redd dewatering analyses estimate the stranding potential associated with a proposed flow change below Keswick Dam.
01.05.2024	Appendix L. CWP Redd Dewatering Analysis	Juvenile stranding and redd dewatering analyses estimate the stranding potential associated with a proposed flow change below Keswick Dam.
01.05.2024	Appendix N. Stanislaus Weighted Usable Area Analysis	Weighted Usable Area analysis used to estimate habitat access and quality in the Stanislaus River.
01.05.2024	Appendix P. Delta Habitat	Delta Habitat analysis evaluates lines of evidence used to understand Delta habitat restoration effectiveness to reduce refuge habitat and food availability and quality stressors.

January 2024 Reclamation-Issued Appendices		
01.12.2024	Appendix I. OMR ECO PTM	The ECO-PTM is an individual-based model that estimates the movement of individual, fish-like particles as they migrate through the Delta under different hydrologic conditions, and conditions affected by the proposed action.

February 2024 Reclamation-Issued Appendices		
Date	**Document**	**Subject/Species**
02.07.2024	Appendix I. Particle Tracking Fate Modeling Larval Entrainment	This application of the PTM is a smelt focused sensitivity analysis using CalSim 3 and DSM2 Hydro to assess relative risk of species at the export facilities under a set of different OMR limits on Delta operations.
02.07.2024	Appendix H. Conservation Measures Deconstruction	The conservation measure deconstruction appendix analyzes actions intended to minimize or compensate for effects of the proposed action or promote the recovery of listed species.
02.07.2024	Appendix I. OMR Flow into Junction Analysis	The Flow into Junctions Analysis estimates the proportion of flow into a distributary channel under the proposed action to evaluate the likelihood of fish movement into junctions.
02.26.2024	BA Trend Report (CalSim3)	The CalSim 3 Trend Report considers flow changes based on climate change projections which were used to consider relative resilience of proposed operations to those changes. Based on July 2023 scenario runs.
02.29.2024	Appendix F. LCA OBAN	The Oncorhynchus Bayesian Analysis (OBAN) uses statistical approaches to understand how environmental driver variables (e.g., temperature and flow) affect SR winter-run Chinook salmon population dynamics.

March 2024 Reclamation-Issued Appendices		
Date	**Document**	**Subject/Species**
03.08.2024	Appendix F. LCA Food Availability Analysis for SRKW & Action Area Map	The Food Availability Analysis is evaluating the estimate of change in abundance of Central Valley Chinook Salmon available to Southern Resident Killer Whales under the Proposed Action. The assessment assumes that 3+ year old Chinook would be the size range most suitable as prey, and thus it solely focuses on age 3+ Chinook salmon.
03.13.2024	TUCP Sensitivity Analysis Trend Report	Excel Sheet
03.20.2024	Appendix K. SCHISM_HSI	The Summer and Fall X2 habitat analysis has HSI calculated using a methodology from 2 papers and with model runs performed using the 3D Bay-Delta SCHISM model. The HSI represents the subregions in the Bay Delta (shown in the pdf) and was based on 4 abiotic variables for sub-adult delta smelt preferred habitat rearing: salinity, temperature, turbidity, and current speed. Overall, historic Delta smelt catch was higher at locations with overlapping conditions of low salinity, low maximum velocity, and high turbidity.

May 2024 Reclamation-Issued Appendices		
Date	**Document**	**Subject/Species**
05.09.2024	Reclamation_2021LTO_ClimateSensitivity_Alt2v2_Analysis	This document summarizes key findings from a sensitivity analysis of climate change scenarios to Alternative (Alt) 2v2 under 2022 Median, 2022 Hot Dry, 2022 Warm Wet, and 2040 Median climates.
05.09.2024	Reclamation_2021LTO_ClimateSensitivity_NAA_Analysis	This document summarizes key findings from a sensitivity analysis of climate change scenarios to the No Action Alternative (NAA) under 2022 Median, 2022 Hot Dry, 2022 Warm Wet, and 2040 Median climates.
05.24.2024	Appendix--ARMFS	The American River Minimum Flow Schedule (ARMFS) was based in large part on the 2017 Flow Management Standard developed by the Water Forum to provide improved American River water supply reliability and water temperature management for fisheries but does have some differences. This document summarizes the ARMFS, including determination of the Minimum Release Requirement (MRR) from Nimbus Dam.

June and July 2024 Reclamation-Issued Appendices		
Date	**Document**	**Subject/Species**
06.04.2024	Reclamation_2021LTO_ClimateSensitivity_Alt2v1 woTUCP_Analysis	Alt2v1woTUCP summarizes key findings from a sensitivity analysis of climate change scenarios to Alternative 2 without Voluntary agreements and without TUCPs (Alt 2v1 wo TUCP) under 2022 Median, 2022 Hot Dry, 2022 Warm Wet, and 2040 Median climates.
06.04.2024	Reclamation_2021LTO_ClimateSensitivity_Alt2v1 wTUCP_Analysis	Alt2v1wTUCP summarizes key findings from a sensitivity analysis of climate change scenarios to Alternative 2 without Voluntary Agreement and with TUCPs (Alt 2v1 w TUCP) under 2022 Median, 2022 Hot Dry, 2022 Warm Wet, and 2040 Median climates.
06.04.2024	Reclamation_2021LTO_ClimateSensitivity_Baselin e_EXP1_Analysis	Baseline EXP1 summarizes key findings from a sensitivity analysis of climate change scenarios to the 'Run of River' scenario (EXP 1) under 2022 Median, 2022 Hot Dry, 2022 Warm Wet, and 2040 Median climates.
06.04.2024	Reclamation_2021LTO_ClimateSensitivity_Baselin e_EXP3_Analysis	Baseline EXP3 summarizes key findings from a sensitivity analysis of climate change scenarios to the 'Obligated Releases' scenario (EXP 3) under 2022 Median, 2022 Hot Dry, 2022 Warm Wet, and 2040 Median climates.
06.27.2024	Appendix-- Winter-Run Juvenile Production Estimate	The annual JPE is used to calculate loss thresholds for Long-Term Operation of the Central Valley Project and the State Water Project, as described in the U.S. Bureau of Reclamation's biological assessment and the NMFS Biological Opinion, and required by CDFW Incidental Take Permit No. 2081-2019-066-00. The Winter-Run PWT's recommendations resulting from this review are described in this appendix.
07.16.2024	BA Trend Report (CalSim3)	The CalSim 3 Trend Report considers flow changes based on climate change projections which were used to consider relative resilience of proposed operations to those changes. Based on September 2023 scenario runs and the basis of all results in Appendix F.

ESA = Endangered Species Act; EFH = Essential Fish Habitat; SR = Sacramento River; CV = Central Valley; CCV = California Central Valley; sDPS = Southern Distinct Population Segment; SRKW = Southern Resident Killer Whale

2. SUMMARY OF THE PROPOSED FEDERAL ACTION

Under the ESA, "action" means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by federal agencies (50 CFR 402.02).

Reclamation operates the CVP for the congressionally authorized purposes of (1) river regulation, improvement of navigation, and flood control; (2) irrigation and domestic uses and fish and wildlife mitigation, protection, and restoration; and (3) power and fish and wildlife enhancement. DWR operates the SWP for the primary purpose of water supply deliveries and flood control, and the SWP provides additional benefits including power generation and environmental stewardship. Public Law 99-546 authorized the 1986 *Coordinated Operations Agreement*, which sets procedures for Reclamation and DWR to share joint responsibilities for meeting Delta standards and other legal uses. Operation of the CVP and SWP also provides recreation and water quality benefits.

The proposed action covers CVP service areas and the operation of CVP dams, power plants, diversions, canals, gates, and related federal facilities located on the watersheds of Clear Creek; the Sacramento, American, Stanislaus, and San Joaquin rivers; and CVP and SWP facilities in the Sacramento-San Joaquin Delta and Suisun Marsh and Bay. For detailed descriptions of the proposed action, see Appendix A of this opinion. For a comparison of Reclamations proposed action to the 2019 proposed action, see Table 3.

Reclamation requested consultation on their proposed action, which is represented by Alternative 2 in the BA and associated appendices and attachments. Alternative 2 consists of three modeling scenarios: Alt2v1 is without Voluntary Agreements (VAs), Alt2v2 includes Delta VAs, and Alt2v3 includes All VAs. Reclamation indicated that Alt2v2 will be implemented for the first 2 years and possibly longer if substantial progress is being made on VAs by year 2 but they have not been approved by the SWRCB. Due to the uncertainty of Alt2v3 occurring, NMFS assumes that Alt2v1 will be implemented beginning at or close to year 3. Therefore, our analysis assumes approximately 2 years of Alt2v2, then 8 years of Alt2v1. More details on the modeling scenarios can be found in Reclamation's Appendix F: Modeling (U.S. Bureau of Reclamation 2023-2024).

The proposed action is organized as follows:

- **Watersheds:** basin-by-basin description of facilities and the proposed operation for fish and wildlife, water supply, and power generation including proposed conservation measures to promote the recovery and/or to minimize or compensate for adverse effects of operation on federally-listed species.
- **Monitoring:** the long-term evaluation of performance to assess overall effectiveness over time. Although each watershed has unique requirements, Reclamation and DWR integrate monitoring across watersheds; therefore, monitoring is organized in a single section.
- **Special Studies:** science-based efforts to address uncertainties in the proposed action that affect a reasonable balance among competing demands for water, including the requirements of fish and wildlife, agricultural, municipal, and industrial uses of water, and power contractors to inform subsequent decision making.

- **Drought:** actions to recognize extreme dry conditions may occur during operations. The boom-and-bust nature of California hydrology and the resulting effect on species warrants special consideration for operation during droughts. Although each drought is unique, contingency planning can facilitate a response.
- **Governance:** ongoing engagement by Reclamation and DWR with USFWS, NMFS, the California Department of Fish and Wildlife (CDFW), interested parties, and the public following completion of the biological opinions and an ROD.
- **Adaptive Management:** science and decision analytic-based approach to evaluate and improve actions, with the aim to reduce uncertainty over time and increase the likelihood of achieving and maintaining a desired management objective.

Basin-by-basin action components are listed below for the Sacramento, American, Stanislaus, and Lower San Joaquin rivers, Clear Creek, and the Delta (for a detailed description of the proposed action, see Appendix A of this opinion):

Sacramento River:
- Shasta Framework for Water Temperature and Reservoir Storage
- Pulse Flows
- Ramping Rates
- Fall and Winter Baseflows for Shasta Refill and Redd Maintenance
- Minimum Instream Flows
- Rice Decomposition Smoothing Flows
- Adult Migration and Holding Temperature Objectives
- SRSCs Resolution

Clear Creek:
- Water Temperature Management
- Ramping Rates
- Minimum Instream Flows
- Pulse Flows
- Segregation Weir

American River:
- Water Temperature Management
- Ramping Rates
- Minimum Instream Flows
- Spring Pulse Flows
- Redd Dewatering Protective Adjustments

Stanislaus River and Lower San Joaquin River:
- Ramping Rates
- Minimum Instream Flows
- Spring Pulse Flows
- Winter Instability Flows
- Fall Pulse Flows

Delta:
- Delta Cross Channel Operations

- Old and Middle River Flow Management
- Spring Delta Outflow
- Delta Smelt Summer and Fall Habitat
- Tracy Fish Collection Facility
- John E. Skinner Delta Fish Protective Facility
- Tidal Habitat Restoration
- Delta Smelt Supplementation
- Water Transfers
- Agricultural Barriers
- Barker Slough Pumping Plant
- Clifton Court Forebay Weed Management
- B.F. Sisk Dam Raise and Reservoir Expansion

The Spring Delta Outflow action has a VA pre-adoption action component and a VA post-adoption action component. For the pre-adoption period, Reclamation and DWR propose to support the Spring Delta Outflow action during March through May, with an emphasis on April and May, with water made available by the CVP and SWP. During the pre-adoption period, Reclamation will support outflow through CVP foregone exports of 0 to 175 thousand acre-feet (TAF) in dry, below normal, and above normal water years for approximately 2 years. Reclamation may continue this pre-adoption action for longer than 2 years if substantial progress is being made to approve VAs, but they are not yet incorporated into the SWRCB's Water Quality Control Plan. DWR's pre-adoption action will be consistent with their ITP application as permitted by the CDFW's ITP (California Department of Fish and Wildlife 2024c), which proposes to curtail exports based on spring flows on the San Joaquin River at Vernalis. DWR's pre-adoption action will be in place until VAs are incorporated into their Water Quality Control Plan and the VA parties execute agreements. Reclamation and DWR propose to operate consistent with the post-adoption action described in the BA (U.S. Bureau of Reclamation 2023-2024) only if the SWRCB approves the VAs, as substantially proposed by the VA parties, and the parties execute or are in the process of executing the agreements associated with the VAs and the SWRCB incorporates the VAs as proposed into their Water Quality Control Plan.

Certain components of the proposed action are considered programmatically; those include:

- The Sites Reservoir Project
- The Delta Conveyance Project (DCP)
- Spring Outflow: Post Adoption of VAs
- Drought Response (i.e., Drought Toolkit)
- Monitoring
- Adaptive Management and Special Studies

We considered, under the ESA, whether or not the proposed action would cause any other activities. We determined that the proposed action would cause the Winter-run Action Plan (WRAP) because the WRAP would not have been proposed and would not occur but for the proposed action. We determined that the WRAP is reasonably certain to occur. The WRAP includes the following components:

- Plan Priorities, including:

    - Thiamine Deficiency Complex Management
    - Reintroduction into Battle Creek and the McCloud River
    - Early Life Stage Survival Science
    - Temperature Control Device Infrastructure Improvement at Shasta Dam
    - Modernization of the Livingston Stone National Fish Hatchery
    - Habitat Restoration and Facility Improvements
- Goals
- Partnerships and Governance
- Science Facilitation and Program Support

2.1. Activities Proposed in the 2019 Consultation That Are No Longer Proposed Under Long-Term Operations

There are several components of the proposed action in the 2019 consultation that are no longer included in the proposed action for this consultation. The following list includes components that were addressed at a site-specific, standard level and some that were addressed programmatically because they were part of larger programs that had existing programmatic consultations or previously analyzed activities within these programs that had stand-alone consultations:

- Operations with a Raised Shasta Dam
- Battle Creek Salmon and Steelhead Restoration Project and Battle Creek Reintroduction Plan - This is action is continuing through other programs
- Actions taken to make water available for Water Transfers
- Spawning and Rearing Habitat Restoration on the Tributaries - This action is continuing through other programs
- Lower San Joaquin River Habitat
- Sacramento Deepwater Ship Channel Food Study
- Delta Cross Channel Improvements
- Sediment Supplementation
- Predator Hotspot Removal
- Clifton Court Forebay Predator Management
- Suisun Marsh/Roaring River Distribution System Food Study

Because these activities are no longer included in the proposed action, effects of these activities are not addressed and incidental take is not exempted in this consultation.

Table 3. Comparison of the current operations and the 2024 proposed action.

Division	*Current Operations*	*2024 Proposed Action*
Sacramento River	Cold Water Pool Management: ● Based on tiered system management hydrology and use of Shasta cold water pool for Sacramento River ● Temperature control device ● SWRCB WRO 90-5 applies. ● SRS resolution ● Sacramento River Temperature Technical Team	Cold Water Pool Management: ● Shasta Framework: A Shasta Management Plan will use a "Bin" approach (Bins 1, 2, and 3), with "A" Bins occurring in lower demand years and "B" Bins occurring during higher demand. ● Integrated drought protection ● Biological objectives for temperature dependent mortality ● Water temperature objectives for adult holding, spawning and egg incubation ● Governance with new Shasta River Group (SRG) and new policy team, the Shasta Operations Team (SHOT) meeting year-round. SHOT coordinates with the Water Operations Management Team (WOMT) 6-agency director group ● SRS resolution ● JPE subteam and SHOT coordination on fish condition (annual viability assessments)
Sacramento River	Strategy for building reservoir storage (an indicator of water temperature management): ● Fall and Winter Refill and Redd Maintenance ● Fall outfall requirements ● Upper Sacramento Scheduling Team	Strategy for building reservoir storage (an indicator of water temperature management): ● End of April and End of September reservoir storage objectives and actions ● End of September reservoir storage objectives ● Governance with SRG and SHOT coordination ● Fall and Winter Refill and Redd Maintenance ● Redd dewatering and rice decomposition smoothing actions ● Fall outfall requirements
Sacramento River	SR winter-run Redd protection: ● Redd dewatering and rice decomposition smoothing ● Upper Sacramento Scheduling Team (USST) coordination	SR winter-run Redd protection: ● Redd dewatering and rice decomposition smoothing ● SRG and SHOT coordination and SHOT decision making

Division	*Current Operations*	*2024 Proposed Action*
Sacramento River	Spring pulse flows: ● Spring pulses up to 150 TAF if projected May 1 storage >4 MAF. ● USST coordination	Seasonal pulse flows: ● Winter or spring pulses up to 150 TAF, when the pulse does not interfere with the ability to meet temperature objectives or other Shasta operations. ● SRG and SHOT coordination and SHOT decision making
Sacramento River	LSNFH integration: ● Increased use of Livingston Stone National Fish Hatchery as part of Drought and Dry Year Actions	LSNFH integration: ● Increased use of Livingston Stone National Fish Hatchery part of Shasta Framework and specifically part of SHOT decision making ● Consideration of annual SR winter-run Chinook salmon fish condition
Sacramento River	Ramping Rates and Minimum Instream Flows	Ramping Rates and Minimum Instream Flows
Sacramento River	Governance: ● SRG, USST and WOMT coordination	Governance: ● SRG, SHOT, WOMT 6-agency Director group
Clear Creek	Minimum Instream Flows: ● Base flow of 200 cfs October 1 through May 31; 150 cfs from June to September in all except critical years. In critical years, base flows may be reduced below 150 cfs based on the available water from Trinity Reservoir.	Minimum Instream Flows: ● Minimum instream (seasonal oscillating) flows will transition from 300 cfs in the winter to 100 cfs in the summer, and back to 300 cfs by the following winter. In critical years, target an average 150 cfs flow based on available water from Trinity Reservoir and attempt to maintain above 100 cfs.
Clear Creek	Pulse Flows: ● 10 TAF for channel maintenance, unless flood control operations provide similar releases, using the river release outlets, in all but dry and critical years, and 10 TAF for spring attraction pulse flows, using the river release, in all but critical years.	Pulse Flows: ● 10 TAF for channel maintenance flows, spring attraction flows, to meet other physical and biological objectives, or 5 TAF during critical years.
Clear Creek	Water Temperature Management: ● Daily average water temperature at the Igo gauge in below normal and wetter years of: ● 60°F from June 1 through September 15 ● 56°F or less from September 15 to October 31 (Operate as close as possible to these targets in dry and critical years)	Water Temperature Management: ● Daily average water temperature at the Igo gauge of: ● 61°F from June 1 through August 15 ● 60°F from August 16 through September 15 ● 56°F from September 16 through November 15 (Operate as close to these temperatures as practicable in critical or import curtailment years)

Division	*Current Operations*	*2024 Proposed Action*
Clear Creek	Governance: ● Clear Creek Technical Team (CCTT) and WOMT coordination	Governance: ● CCTT, SHOT, WOMT, 6-agency Director-level resolution and decision-making process
American River	Flow Management: ● 2017 Flow Management Standard: Flows range from 500 to 2,000 cfs based on time of year, annual hydrology, and "planning minimum" ● American River Group (ARG) and WOMT coordination	Flow Management: ● 2017 Flow Management Standard: Flows range from 500 to 2,000 cfs based on time of year, annual hydrology, and "planning minimum" ● Governance with ARG and WOMT coordination and 6-agency director group
American River	Water Temperature Management: ● May 15 through October 31 daily average water temperature of 65°F (or target temperature determined by temperature model) or lower at Watt Avenue Bridge. When the target temperature requirement cannot be met because of limited cold water availability in Folsom Reservoir, then the target daily average water temperature at Watt Avenue may be increased incrementally (i.e., no more than 1°F every 12 hours) to as high as 68°F. ● November 1 through December 31 daily average water temperature of 56°F target if cold water pool allows. A temperature higher than 56°F may be targeted based on temperature modeling results. ● ARG and WOMT coordination	Water Temperature Management: ● Monthly water temperature targets at the Watt Avenue bridge range from 63°F to 72°F depending on the schedule. If temperature thresholds are exceeded for 3 consecutive days or by more than 3°F in a single day, Reclamation will inform NMFS and the American River Group, outlining steps to realign water temperature with the Temperature Management Plan. ● ARG and WOMT Coordination, 6-agency director group
American River	Ramping Rates • Established ramping rates with option for alternative rates on a case-by-case basis in coordination with ARG	Ramping Rates • Established ramping rates with option for alternative rates on a case-by-case basis in coordination with ARG for monitoring and maintenance
American River	Governance: ● American River Group (ARG) and WOMT coordination	Governance: ● ARG, WOMT, 6-agency Director-level resolution and decision-making process
Stanislaus River	Stepped Release Plan (SRP): • Stanislaus Watershed Team (SWT) and WOMT coordination	Stepped Release Plan (SRP): Seasonal Operations (same objectives as SRP) • Stanislaus Watershed Team (SWT) and WOMT coordination, 6-agency director group

Division	*Current Operations*	*2024 Proposed Action*
Stanislaus River	Minimum Instream Flows: • Minimum Instream Flows (per SRP)	Minimum Instream Flows: • Minimum Instream Flows (per SRP with slight modifications to winter instability flows)
Stanislaus River	Ramping Rates: • Established ramping rates with option for SWT to consider alternative rates on a case-by-case basis with monitoring in place	Ramping Rates: • Established ramping rates with option for SWT to consider alternative rates on a case-by-case basis with monitoring in place
San Joaquin River	Flows in the main stem San Joaquin River that include managed tributary inputs and San Joaquin River Restoration Program (SJRRP) flows	Seasonal Conditions from the Stanislaus River Confluence to the Delta
Delta	Delta Cross Channel Gates: ● Delta Cross Channel operations based on D-1641, closures for fish protections, and operations that avoid exceeding water quality standards. ● SAMT and WOMT coordination	Delta Cross Channel Gates: ● Delta Cross Channel operations based on D-1641, closures for fish protections, and operations that avoid exceeding water quality standards. ● SAMT and WOMT coordination
Delta	Delta Outflow: ● Delta outflow to meet D-1641 requirements; Suisun Marsh Salinity Control Gate operation for up to 60 additional days between June 1 and October 31, depending on year type; increased Delta outflow in wet and above normal year types in certain conditions. ● No independent spring outflow action for the CVP	Delta Outflow: ● CVP: Spring Delta Outflow (pre-adoption) for approximately 2 years, in above normal/below normal/dry years. After approximately 2 years, OMR management ● Delta outflow to meet D-1641 requirements; Suisun Marsh Salinity Control Gate operation for up to 60 additional days between June 1 and October 31, depending on year type; increased Delta outflow in wet and above normal year types in certain conditions. ● SWP: Pre-adoption of the VAs, implementation of the ITP action for duration of permit (November 1 2034).

Division	*Current Operations*	*2024 Proposed Action*
Delta	Old and Middle River Management: ● January 1 onramp ● Flows based on species distribution, modeling, and risk analysis with provisions for capturing storm flows ● Single year and cumulative loss thresholds SR winter-run Chinook salmon and CCV steelhead. ● Coleman surrogate releases for CV spring-run entrainment triggers ● Length-at-date fish identification ● Date and temperature offramps	Old and Middle River Management: ● Old and Middle River Managed Reverse flows based on species distribution, modeling, and risk analysis with provisions for capturing storm flows ● Early season SR winter-run Chinook salmon triggers ● Weekly distributed loss thresholds for SR winter-run Chinook salmon, CV spring-run Chinook salmon and CCV steelhead ● CV spring-run Chinook salmon surrogate threshold ● Spring Outflow ● Use of genetic identification ● Date and temperature offramps with additional temperature site ● Governance with SAMT and WOMT coordination and 6-agency director group
Delta	Agricultural Barriers	Agricultural Barrier - construction as early as May 1 each year
Delta	1986 Coordinated Operations Agreement between Reclamation and DWR, with 2018 Addendum	1986 Coordinated Operations Agreement between Reclamation and DWR, with 2018 Addendum
Delta	Fish salvage facilities: ● Fish facility protocols	Fish salvage facilities: ● Fish facility protocols ● Alternative Loss Pilot Study Implementation Plan (ALPS-IP) as an action that will help to better quantify take at the export facilities
Delta	Water transfers	Water transfers
Delta	Governance: ● Salmon Monitoring Team (SAMT) and WOMT coordination	Governance: ● SAMT, WOMT, 6-agency Director-level resolution and decision-making process
Framework Programmatic Actions	● Lower Intakes near Wilkins Slough ● Spawning Gravel Injections ● Side Channel Habitat Restoration ● Small Fish Screen Program	● Sites Reservoir and Delta Conveyance Project ● Spring Delta Outflow - post VA adoption ● Drought Response: Drought Toolkit ● Tidal Habitat Restoration (remaining 5,677 acres) ● Adaptive Management Actions ● Monitoring

3. ANALYTICAL APPROACH

3.1. Introduction

This section describes the analytical approach used by NMFS to evaluate the likely effects of the proposed action on listed species under NMFS jurisdiction and critical habitat designated for those species. The approach is intended to ensure that NMFS comports with the requirements of the statute and regulations when conducting and presenting the analysis. Section 7(a)(2) of the ESA requires federal agencies, in consultation with NMFS, to ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species; or destroy or adversely modify their designated critical habitat. To that end, this opinion includes both a jeopardy analysis and an adverse modification analysis.

The jeopardy analysis relies upon the regulatory definition of "jeopardize the continued existence of" a listed species, which is "to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species" (50 CFR 402.02). Therefore, the jeopardy analysis considers both survival and recovery of the species. Likewise, this opinion relies on the regulatory definition of "destruction or adverse modification," which "means a direct or indirect alteration that appreciably diminishes the value of critical habitat as a whole for the conservation of a listed species" (50 CFR 402.02). "Such alterations may include, but are not limited to, those that alter the physical or biological features essential to the conservation of a species or that preclude or significantly delay development of such features" (81 FR 7214, February 11, 2016).

The designations of critical habitat for some of the listed species included in this consultation use the term primary constituent element (PCE) or essential features. The 2016 final rule (81 FR 7414, February 11, 2016) that revised the critical habitat regulations (50 CFR 424.12) replaced this term with physical or biological features (PBFs). The shift in terminology does not change the approach used in conducting a "destruction or adverse modification" analysis, which is the same regardless of whether the original designation identified PCEs, PBFs, or essential features. In this opinion, we use the term PBF to mean PCE or essential feature, as appropriate for the specific critical habitat.

Effects of the action are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action but that are not part of the action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action (89 FR 24268, April 5, 2024). Because they are such closely related terms, we use the terms "effects," "consequences," and "impacts" interchangeably in this opinion.

The ESA and its implementing regulations require NMFS to use the best scientific and commercial data available to complete formal consultations. Although the ESA does not explicitly define the "best scientific and commercial data," nor is there a publicly available administrative definition (Doremus 2004), the USFWS and NOAA have provided a cooperative policy statement concerning information standards under the ESA (59 FR Uncategorized, July 1,

1994). That policy primarily focuses on procedural issues, such as the importance of impartiality, documentation of best available science evaluation, and the use of primary sources, but the substantive aspects of what does or does not comprise best available science remains closely tied to the facts of any individual project (Lowell and Kelly 2016). The final determination of whether or not the proposed action is likely to jeopardize the species' continued existence or destroy or adversely modify its critical habitat will be the product of a multi-layered analytical approach in which many of the intermediate results have associated degrees of uncertainty. When considering the uncertainty of the data, analytical methods, and results, NMFS applies the best scientific and commercial data available, accepted scientific techniques, and best professional judgment rather than applying a presumption in favor of the species.

We use the following approach to determine whether a proposed action is likely to jeopardize listed species or destroy or adversely modify critical habitat:

- Evaluate the rangewide status of the species and critical habitat expected to be adversely affected by the proposed action
- Evaluate the environmental baseline of the species and critical habitat
- Evaluate the effects of the proposed action on species and their critical habitat using an exposure-response approach
- Evaluate cumulative effects
- In the integration and synthesis, add the effects of the action and cumulative effects to the environmental baseline, and, in light of the status of the species and critical habitat, analyze whether the proposed action is likely to: (1) directly or indirectly reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species; or (2) directly or indirectly result in an alteration that appreciably diminishes the value of critical habitat as a whole for the conservation of a listed species
- If necessary, suggest a reasonable and prudent alternative to the proposed action

The subsections below outline the specific framework, key steps, assumptions, and professional judgment NMFS used to assess the effects of the proposed action on listed species and critical habitat. The subsections of the analytical approach are as follows:

- Section 3.2 Legal and Policy Framework: This section describes the relevant aspects of the legal and policy framework provided by the ESA, implementing regulations, case law, and policy guidance related to ESA section 7 consultations that informs and/or directs our analytical approach.
- Section 3.3 Summary of CalSim Modeling Scenarios Used in the Effects Analysis: This section describes how we considered different CalSim modeling scenarios to analyze the effects of the proposed action on species and critical habitat.
- Section 3.4 Overview of the Approach and Conceptual Models: This section provides a general overview of how NMFS conducts its ESA section 7 analysis. It includes various conceptual models of the overall approach and specific features of the approach. It also includes information on tools that NMFS used in the analysis specific to this consultation. The section first describes the listed species analysis as it pertains to individual fish species and the physical, chemical, and biotic changes to the ecosystem caused by the proposed action. It then describes the critical habitat analysis.

- Section 3.5 Evidence Available for the Analysis: This section discusses the primary analytical models and operational scenarios, assumptions and areas of uncertainty that were considered in the analysis.
- Section 3.6 Integrating the Effects: This section describes the overall conceptual approach in the assessment to address integration of all available information and decision frameworks to support the assessment of the effects of the proposed action.
- Section 3.7 Presentation of the Analysis in This Opinion 3.7, Presentation of the Analysis in this Opinion: This section discusses the presentation of all analyses within this opinion as a guide to locating results of specific analytical steps.

Wherever possible, these subsections apply to all five listed species and associated designated critical habitats occurring in the action area. The listed species and critical habitat include the following:

- Endangered SR winter-run Chinook salmon ESU and its designated critical habitat
- Threatened CV spring-run Chinook salmon ESU and its designated critical habitat
- Threatened CCV steelhead DPS and its designated critical habitat
- Threatened sDPS of North American green sturgeon and its designated critical habitat
- Endangered Southern Resident killer whale DPS and its designated critical habitat

NMFS has evaluated the proposed action for this consultation as a "mixed programmatic" action as defined by 50 CFR 402.02 because it includes some action components for which no additional authorization will be necessary and others that are considered at a framework-level (see Table 1). Programmatic consultations allow the Services (NMFS and USFWS) to consult on the effects of programmatic actions such as: (1) multiple similar, frequently occurring, or routine actions expected to be implemented in particular geographic areas; and (2) a proposed program, plan, policy, or regulation providing a framework for future proposed actions. Proposed action components that are considered at a framework level are analyzed at a broad scale such that exemption from take prohibitions are not provided in the incidental take statement of this opinion. Once framework-level action components are further developed and sufficient detail is available to determine the amount and extent of incidental take, they will require additional ESA section 7 consultation before implementation; this subsequent consultation will include an incidental take statement for those components. Components that do not require additional authorization are analyzed in this opinion and exemptions from take prohibitions are provided in the incidental take statement of this opinion.

For components of the proposed action that lack specificity in their description that is otherwise required to analyze a particular effect in detail, NMFS applies the best scientific and commercial data available, accepted scientific techniques, and best professional judgment to analyze the range of effects that could result. This approach, paired with NMFS' identification of framework-level action components and the inclusion of additional analytical methods not used in the BA, could result in NMFS drawing different conclusions than the action agency's conclusions in the BA. We identify the lines of evidence to support NMFS' conclusions in the Effects of the Action and Integration and Synthesis sections of this opinion.

3.2. Legal and Policy Framework

Consultations designed to allow federal agencies to fulfill the requirements of section 7 of the ESA conclude with issuing a biological opinion or a concurrence letter. Section 7 of the ESA, implementing regulations (50 CFR 402.14), and associated guidance documents result in formal biological opinions that present the following:

- A description of the proposed federal action
- A summary of the status of the affected species and its critical habitat
- A summary of the environmental baseline within the action area as defined in the ESA implementing regulations (50 CFR 402.02)
- A detailed analysis of the effects of the proposed action on the affected species and critical habitat
- A description of cumulative effects
- A conclusion as to whether or not it is reasonable to expect that the proposed action is not likely to appreciably reduce the species' likelihood of both survival and recovery in the wild by reducing its reproduction, numbers, or distribution or result in the destruction or adverse modification of the species' designated critical habitat

The purpose of the jeopardy analysis is to determine whether appreciable reductions in the likelihood of both the survival and recovery of the species in the wild are reasonably expected, but not to precisely quantify the amount of those reductions. As a result, this assessment often focuses on whether an appreciable reduction is expected or not; it does not focus on detailed analyses designed to quantify the absolute amount of reduction or the resulting population characteristics (absolute abundance, for example) that could occur as a result of implementing the proposed action.

For Pacific salmon, steelhead, and certain other species such as sturgeon, we commonly use four "viable salmonid population" (VSP) parameters (McElhany et al. 2000) to assess the viability of the populations that, when considered together, provide the basis of understanding used to determine the likelihood of survival and recovery of the species. When these parameters are collectively at a level indicating a "negligible risk of extinction," they maintain a population's capacity to adapt to various environmental conditions and allow it to sustain itself in the natural environment. A designation of "a high risk of extinction" or "low likelihood of becoming viable" indicates that the species faces significant risks from internal and external processes that can drive it to extinction. The VSP parameters of productivity, abundance, and population spatial structure are consistent with the "reproduction, numbers, or distribution" referenced within the regulatory definition of "jeopardize the continued existence of" (50 CFR 402.02) and are used as surrogates for "reproduction, numbers, or distribution." The fourth VSP parameter of diversity relates to all three. For example, reproduction, numbers, and distribution are all affected when genetic or life history variability is lost or constrained, resulting in reduced population resilience to environmental variation at local or landscape levels.

McElhany et al. (2000) highlight that the VSP framework will include "a degree of uncertainty in much of the relevant information," and as such, the proposed action provides a specific approach to the adaptive management of the project components, which is outlined in the Adaptive Management Program (AMP) received on December 7, 2023. The AMP and associated appendices (AMP Appendix A and B in U.S. Bureau of Reclamation 2023-2024) identify project

components where Reclamation and coordinating agencies have acknowledged a level of scientific uncertainty which may be resolved through further study and considered in management decisions. NMFS encourages the utilization of the AMP as a means to address those uncertainties which have been identified and which are associated with the efficacy of management actions. A robust adaptive management component can address the uncertainty identified by McElhany et al. (2000), thereby filling critical data and information gaps, enhancing the existing monitoring network, and improving quantitative modeling capabilities.

In addition to the evaluation of the VSP parameters and the consideration of extinction risk, NMFS notes the regulatory definition of "jeopardize the continued existence of" includes the term "recovery" (50 CFR 402.02). NMFS finalized recovery plans for the listed Central Valley salmon and steelhead species in 2014 (National Marine Fisheries Service 2014b) and for the listed sDPS of green sturgeon in 2018 (National Marine Fisheries Service 2018e). These recovery plans, which include recovery objectives and criteria, also identify stressors or threats to the recovery of the species throughout their life cycles. This consultation uses the primary stressor and threat categories from the recovery plans as the basis for identification of potential stressors that could result from the proposed action and therefore could not only appreciably reduce the likelihood of survival of the species but also the likelihood of recovery of the species.

The information from recovery plans, the most recent 5-year reviews, and the NMFS-SWFSC's viability report (National Marine Fisheries Service 2023d) for each species represent the best scientific and commercial data available describing their respective current status, and were, therefore, incorporated into this opinion. A technical recovery team that assisted in the Central Valley salmonids recovery planning effort produced a "Framework for Assessing Viability of Threatened and Endangered Chinook Salmon and Steelhead in the Sacramento-San Joaquin Basin" (Lindley et al. 2007). Along with assessing the current viability of the listed Central Valley salmon and steelhead species, Lindley et al. (2007) made recommendations for recovering those species. The framework was used to inform the current status of the listed Central Valley salmon and steelhead species within this opinion. The recovery plans, 5-year reviews, and Lindley et al. (2007) were used as the foundation to determine whether consequences of the proposed action, when added to the environmental baseline and cumulative effects, would be expected to "reduce appreciably the likelihood of both the survival and recovery of a listed species." NMFS has also applied this framework in analyzing likely effects to survival and recovery of the sDPS of green sturgeon, a species represented by a single spawning population, much like the SR winter-run Chinook salmon population.

Additional requirements for the analysis of the effects of an action are described in regulations (50 CFR 402). The conclusions related to "jeopardize the continued existence of" and "destruction or adverse modification" require an expansive evaluation of direct and indirect consequences of the proposed action, and the overall context of the impacts to the species and habitat from past, present, and future actions as well as the condition of the affected species and critical habitat (for example, see the definitions of "cumulative effects" and "effects of the action" in 50 CFR 402.02 and the requirements of 50 CFR 402.14(g)).

Recent court cases have reinforced the requirements provided in the ESA section 7 implementing regulations that NMFS must evaluate the effects of a proposed action within the context of the current condition of the species and critical habitat, including other factors affecting the survival

and recovery of the species and the functions and value of critical habitat for the conservation of the species. Furthermore, our risk assessments must consider the effects of climate change on the species and critical habitat and our analysis of the future impacts of a proposed action. NMFS acknowledges that the effects of climate change could have notable impacts on listed species while also recognizing the challenge in quantifying those effects. Conservation of protected resources becomes more difficult when considering a changing climate, especially when accounting for the relative uncertainty of the rate and magnitude of climate-related changes and the response of organisms to those changes. Accordingly, NMFS issued general policy guidance for the treatment of climate change in ESA decisions (Sobeck 2016). This guidance, which was renewed on February 15, 2023 (Somma 2023), aligns with case law, noting the need to consider climate change in determinations and decisions despite the challenges of climate change uncertainty, and it provides policy considerations related to climate change that NMFS should use in ESA decision making, including ESA section 7 consultations.

Climate change is incorporated into this analysis implicitly to an extent by the CalSim 3 modeling results provided in the BA and additionally by qualitative evaluations of climate-related risk that reflect more recent climate trends applied in the opinion. The modeling of the proposed action as provided in the BA characterizes a 2037 scenario of climate conditions, water demands, and build-out. In doing so, the proposed action uses 40 Coupled Model Intercomparison Project 5, global climate model (GCM) projections. These projections were downscaled using the localized constructed analog (LOCA) method at 1/16-degree spatial resolution (Pierce et al. 2014). The LOCA method is a statistical scheme that uses future climate projections combined with historical analog events to produce daily downscaled precipitation and maximum and minimum temperature time series data. The 40 climate projections were generated with 20 GCMs and two emission scenarios (i.e., Representative Concentration Pathways [RCPs]): one optimistic (RCP 4.5) and one pessimistic (RCP 8.5). These RCPs are the same as those used to inform the Intergovernmental Panel on Climate Change's (IPCC) Sixth Assessment Report, where the new climate models use RCPs coupled with internally consistent Shared Socioeconomic Pathways (SSPs). The SSPs describe five possible futures of population growth, energy use, technological change, and environmental conditions to better estimate global emissions to 2100. Although NMFS guidance encourages the use of SSP3-7.0 when data are available, when data specific to that pathway are not available, NMFS will use the best available science that is as consistent as possible with SSP3-7.0.

For the purposes of the BA, the future climate change scenario (2022±15 median climate condition) was developed using the bias-corrected daily precipitation and detrended daily temperature using the quantile mapping approach based on the selected 40 GCM projections. Ultimately, the change in long-term average temperature for the major watersheds in the Sacramento and San Joaquin river basins under the 2022±15 median climate change scenario is projected to increase by 1.6°C across the major watersheds with a minimum increase of 1.4°C with respect to the historical reference period (1995). The highest temperature increases are projected for the Feather River (1.7°C) watershed in the Sacramento river basin and Merced River (1.7°C) watershed in the San Joaquin river basin. Likewise, the projected change in long-term average precipitation for the major watersheds in the Sacramento and San Joaquin river basins are projected to be wetter under the 2022 ± 15 median condition, with average increases from 0.9 percent to 2 percent. The Sacramento river basin is projected to experience a higher increase in long-term average precipitation relative to the San Joaquin river basin.

The BA results, which characterize climate change conditions to 2037, provide an estimate of projected temperature and precipitation changes that are reasonably consistent with California's Fourth Climate Change Assessment (He et al. 2018, Pierce et al. 2018). As provided by the assessment, NMFS assumes that temperatures would increase up to 1.9°C between 2020 and 2059 and precipitation changes would range from -6 percent to +24 percent in the same period (He et al. 2018). Sea level rise is expected to range up to 15 centimeters in 2037 and 10 to 38 centimeters in 2050 (Pierce et al. 2018). All of these predicted changes, however, provide only a coarse understanding of how a future environment will affect NMFS-trust resources, where a species' response to temperature and flow reflect a complex function of magnitude, duration, and timing that is not necessarily captured in the BA modeling.

Longer-term responses to climate uncertainty can be incorporated into a reinitiation trigger focused on regular assessments of adherence to the climate assumptions used in the analysis of this opinion. To address shorter-term deviation from the current predictions, NMFS expects to be able to incorporate climate uncertainty into the AMP planning by including monitoring of climate change effects and projections; taking management actions; and adjusting water operations, research, and monitoring in response as needed. Such responses may include, for instance, identifying alternative locations for implementing restoration or habitat protection actions to increase habitat availability and suitability, increasing productivity of the food web, better managing predators and invasive species, or allowing species movement across environmental gradients. Adjustments to water operations associated with inflow, outflow, and exports are another example of potential responses to approaching reinitiation triggers.

3.3. Summary of CalSim Modeling Scenarios Used in the Effects Analysis

The following subsections provide descriptions of each modeling scenario used to determine effects to listed species and critical habitat in this opinion.

3.3.1. Effects of the Proposed Action

We used the proposed action modeling (Alt2v1 or Alt2v2) to analyze the effects that the action is having on species and critical habitat. These scenarios provide a modeled representation of the conditions that the fish experience, which captures both the discretionary and non-discretionary effects of the proposed action. While we acknowledge the non-discretionary effects included in the Alt2v1 and Alt2v2 modeling belong in the environmental baseline, we analyze them in the Effects of the Action section because they provide the best available information describing the consequence of the action.

3.3.2. Use of the No Action Alternative/Current Operations Scenario to Understand the Trajectory of Stressors and Effects of the Proposed Action

The No Action Alternative (NAA) modeling scenario represents the past and present impacts of all federal, state, or private actions, which include the current discretionary and non-discretionary operations of the CVP and SWP. The NAA was used to provide a point of reference for changes to the operations within the context of other existing human activities that impact the listed species but not to determine discretionary effects of the proposed action.

3.3.3. Use of the EXP3 Scenario to Represent Impacts of the Non-Discretionary Operations of the Proposed Action

In this opinion, we used experimental CalSim 3 scenarios to represent the impacts of the non-discretionary operations of the proposed action that are addressed in the environmental baseline. To do this, we utilize the EXP3 (Obligated Releases Scenario) modeling scenario which Reclamation developed to describe the effects of the non-discretionary operations of the CVP and SWP (U.S. Bureau of Reclamation 2023-2024, Appendix F: Modeling). Despite EXP3 including the majority of non-discretionary operations, there are certain instances where non-discretionary obligations are not included in the EXP3 modeling scenario (e.g., temperature compliance per SWRCB Order 90-5) because Reclamation retains some discretion over how compliance will be met. Using EXP3 modeling results helps illustrate how Reclamation's discretion is exercised to influence the direction of stressors.

3.3.4. Proposed Action Scenarios Used to Determine Effects to Listed Species and Critical Habitat

Reclamation provided four proposed action scenarios: Alternative 2 version 1 (Alt2woTUCPwoVA or Alt2v1), Alternative 2 version 2 (Alt2woTUCPDeltaVA or Alt2v2), Alternative 2 version 3 (Alt2woTUCPAllVA or Alt2v3), and with TUCPs (Temporary Urgency Change Petitions) without VAs (Voluntary Agreements; Alt2wTUCPwoVA). These scenarios are possible phases of the proposed action, which is expected to be an ongoing action but considered for ten years in this consultation. Alt2v1 represents the proposed action without any VAs implemented; this scenario is expected to occur from year 3 to year 10. Alt2v2 includes operations that mirror implementation of some assets of the Delta component of the VAs, which are reduced exports in the Delta that are intended to result in greater outflow; this scenario is expected to occur for the first 2 years of implementation. Alt2v3 is not expected to occur. Since Alt2v1 and Alt2v2 do not affect upstream conditions (i.e., Alt2v2 only changes Delta conditions), and the modeling results for the two scenarios appear to be the same outside of the Delta (see Appendix F: Modeling in U.S. Bureau of Reclamation 2023-2024), NMFS treats the consequences of the two operational scenarios as effectively the same outside of the Delta. Therefore, for upstream division effects analyses, Alt2v1 modeling results were relied upon to provide the most likely conditions resulting from the proposed action for the duration of the analyzed time frame (i.e., 10 years). The Bay-Delta Division effects analysis relies on Alt2v2 for 2 years and then Alt2v1 for the remainder of years.

3.4. Overview of the Approach and Conceptual Models

NMFS uses a series of sequential activities and analyses to assess the effects of federal actions on endangered and threatened species and designated critical habitat. These sequential activities and analyses are illustrated in Figure 1 for listed species and Figure 2 for critical habitat. The final step in the series integrates the conclusions drawn from these activities, summarizing analyses in table format with consistent terms to facilitate the review of effects. In order for us to analyze the proposed action, it was first separated into components (deconstructed) for each division (as described in the BA). The first analysis uses the identified proposed action components and other activities that resulted from the deconstruction of the proposed action to identify environmental stressors. Specifically, the physical, chemical, or biotic aspects of the proposed action that are likely to have individual, interactive, additive direct or indirect effects

on the environment. As part of this step, NMFS identifies the spatial and temporal extent of both the proposed action components and any potential stressors, recognizing that the spatial extent of the stressors may change with time. NMFS notes that the spatial extent of potential stressors may extend beyond the geographic area included in the project description (i.e., a project description of in-Delta operations may have effects that extend upstream; the spatial extent of those effects is traced as part of this analysis).

The next step in the series of analyses starts by identifying the threatened or endangered species or designated critical habitat that are likely to be exposed to (occur in the same space and at the same time as) the potential stressors and their spatial extent. We estimate the nature of co-occurrence of individuals and effects to represent the individual exposure assessment. In this step, we identify the proportion of a population (or number of individuals, when available) and age (or life stage) that are likely to be exposed to an action's effects, and the specific areas and PBFs of critical habitat that are likely to be affected. We then assess the severity or magnitude of an effect based on expected impact to the individual or the expected impact to PBFs and value for conservation of critical habitat. Likewise, when considering the severity of the effect of multiple contemporaneous stressors that may be additive or nonadditive (e.g., synergistic, or antagonistic), our analysis provides an estimation of the net effect. Finally, we consider the incidence of exposure based on the activities in the description of the proposed action.

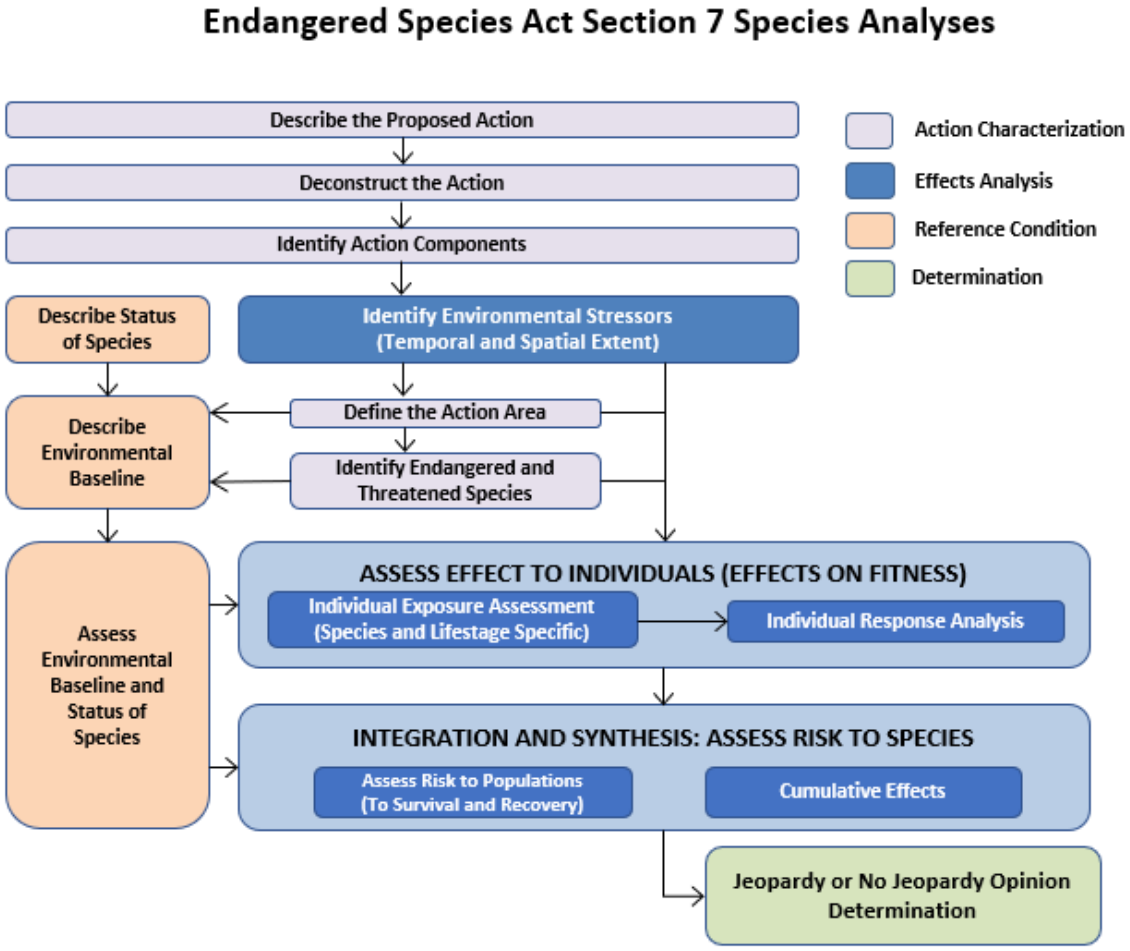


Figure 1. General conceptual model for conducting Endangered Species Act section 7 analyses as applied to listed species.

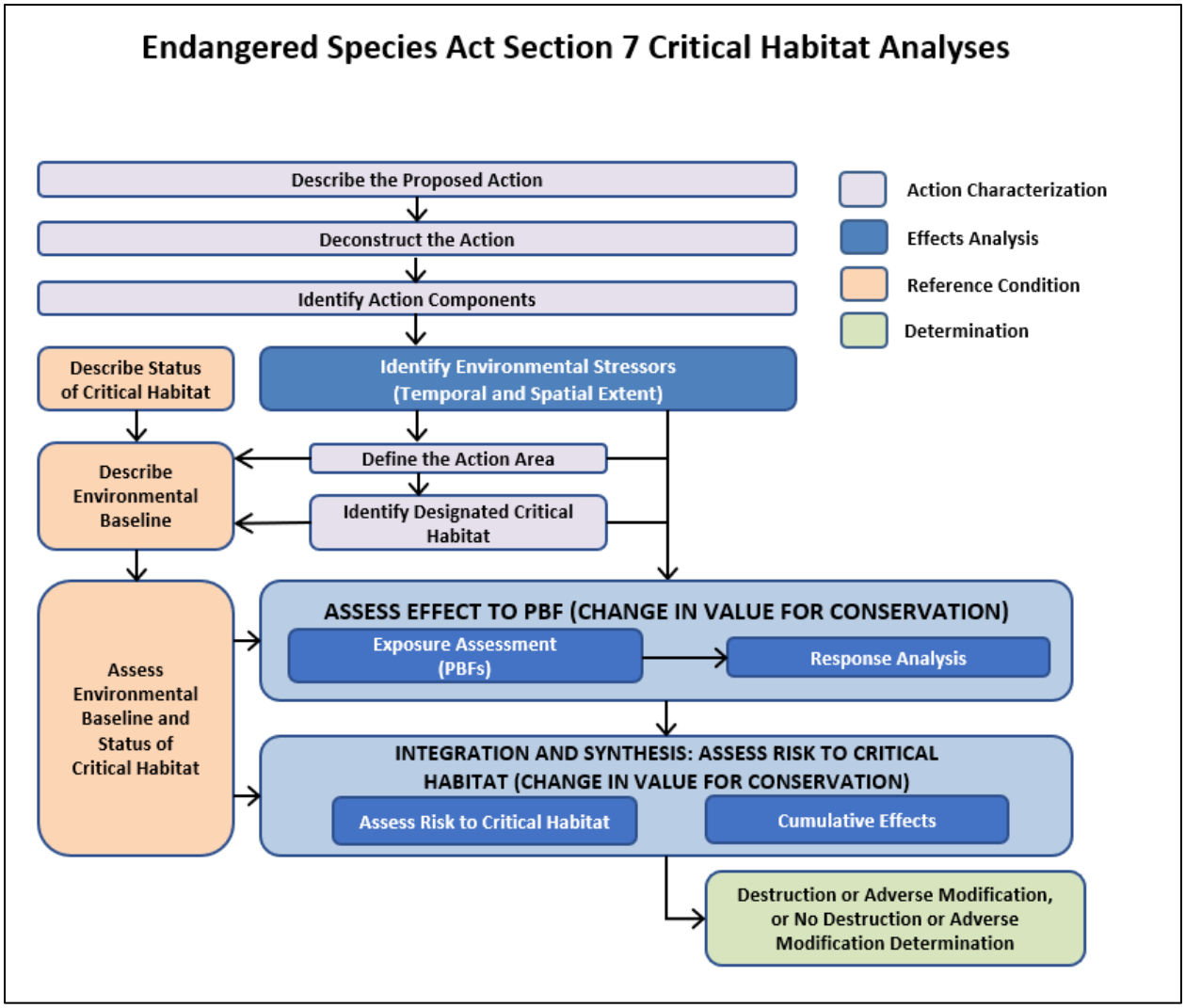


Figure 2. General conceptual model for conducting Endangered Species Act section 7 analyses as applied to critical habitat.

Once we identify which listed resources (i.e., endangered and threatened species and designated critical habitat) are likely to be exposed to potential stressors associated with an action and the nature of the exposure, we examine the best scientific and commercial data available to determine whether and how those listed resources are likely to respond given their exposure to the proposed action. This represents the individual response analysis. Depending on the information available in the exposure and response analysis, the analysis may rely on slightly different approaches. For example, where there exist less well understood relationships between particular stressors and the species response, we may evaluate the effects of the action using a conceptual model such as the Salmon and Sturgeon Assessment of Indicators by Life Stage (SAIL) model described below. In other cases, we may use the result of quantified modeling to attempt to identify the effects of the proposed action.

The final steps of our series of analyses establish the risks those responses pose to listed resources, with recognition that responses of individuals may differ within and between (subwatershed) populations and across different diversity strata within a species. These steps represent our risk analysis. They are different for listed species and designated critical habitat and are discussed in the following sections.

3.4.1. Application of the Approach to Listed Species Analyses

Our jeopardy determinations must be based on a proposed action's effects on the likelihood of survival and recovery of threatened or endangered species as listed (e.g., as true biological species, subspecies, or distinct population segments of vertebrate species). Because the continued existence of listed species depends on the fate of the populations that comprise them, the probability of extinction or probability of persistence of listed species depends on the probabilities of extinction and persistence of the populations that comprise the species. Similarly, the continued existence of a population is determined by the fate of the individuals that comprise it; populations grow or decline as the individuals that comprise the population live, die, grow, mature, migrate, and reproduce (or fail to do so). The different approaches used for specific species are included below in Section 3.4.1.1 for salmonids and sturgeon and Section 3.4.1.2 for SRKWs.

3.4.1.1. The Viable Salmonid Populations Framework Approach for Listed Salmonids and Southern Distinct Population Segment of Green Sturgeon

While McElhany et al. (2000) specifically addresses viable populations of salmonids, NMFS also applies the concepts and viability parameters described in McElhany et al. (2000) to the management and recovery planning for sDPS green sturgeon (National Marine Fisheries Service 2018e). Due to the general similarity in life cycle and freshwater/ocean use, NMFS uses the same conceptual approach to identifying demographic recovery criteria and to assess the extinction risk for both sturgeon and salmonids (National Marine Fisheries Service 2021i, 2024a). Therefore, in this opinion, NMFS applies McElhany et al. (2000) and the viability parameters in its characterization of the status of the species, environmental baseline, and analysis of the effects of the action to both salmonids and sDPS green sturgeon.

We nest the VSP concept within the hierarchy of the individual-population-diversity group ESU/DPS relationships to evaluate the potential impact of the proposed action. For the species, the conceptual model is based on a bottom-up hierarchical organization of individual fish at the life stage scale, population, diversity group (if applicable), and ESU/DPS (Figure 3). The viability of a species (e.g., ESU) is dependent on the viability of the population(s) or diversity groups that compose that species and the spatial distribution of those groups or populations; the viability of a diversity group is dependent on the viability of the population(s) that compose that group and the spatial distribution of those population(s); and the viability of the population is dependent on the four VSP parameters. The top of this VSP hierarchy is ultimately expressed by the abundance of individuals at the life stage scale.

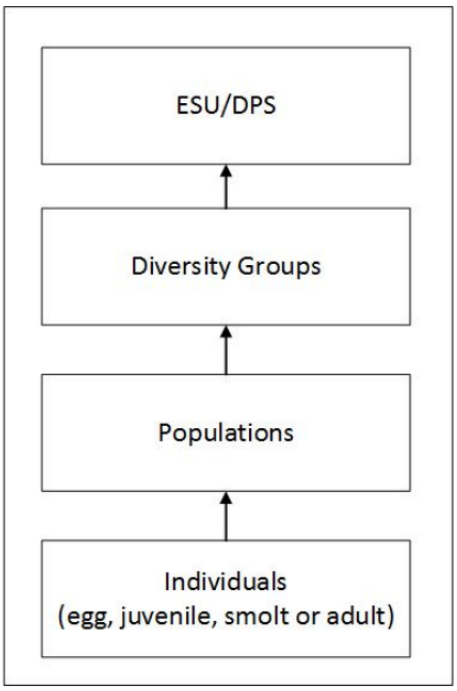


Figure 3. Conceptual model of the hierarchical structure that is used to organize the jeopardy risk assessment for anadromous salmonids and green sturgeon.

Our analyses reflect these relationships where we identify the anticipated consequences of the proposed action to listed individuals that are likely to be exposed to the action. Our analyses then integrate the individuals' response to the proposed action to identify consequences to the proportion of populations represented by the individuals (Figure 1). Finally, our analyses determine the consequences of those population level risks to the species that the populations comprise.

The VSP concept provides the framework for estimating the viability of populations and larger-scale groupings of Pacific salmonids such as at the ESU or DPS level. Four VSP parameters form the key to evaluating population and ESU/DPS viability: (1) abundance; (2) productivity (i.e., population growth rate); (3) population spatial structure; and (4) diversity (McElhany et al. 2000). These four parameters and their associated attributes are presented in Figure 4.

As presented in the NMFS' Recovery Plan for CV salmonids (2014b), criteria for VSP are based upon measures of the VSP parameters that reasonably predict extinction risk and reflect processes important to populations. Abundance is critical because small populations are generally at greater risk of extinction than large populations. Stage-specific or lifetime productivity (i.e., population growth rate) provides information on important demographic processes. Genotypic and phenotypic diversity are important because they allow species to use a wide array of environments, respond to short-term changes in the environment, and adapt to long-term environmental change. Spatial structure reflects how abundance is distributed among available or potentially available habitats and can affect overall extinction risk and evolutionary processes that may alter a population's ability to respond to environmental change. However,

each of these parameters, and the criteria that can be developed from them, must be sensitive to the uncertainty of estimates, levels, and processes (McElhany et al. 2000).

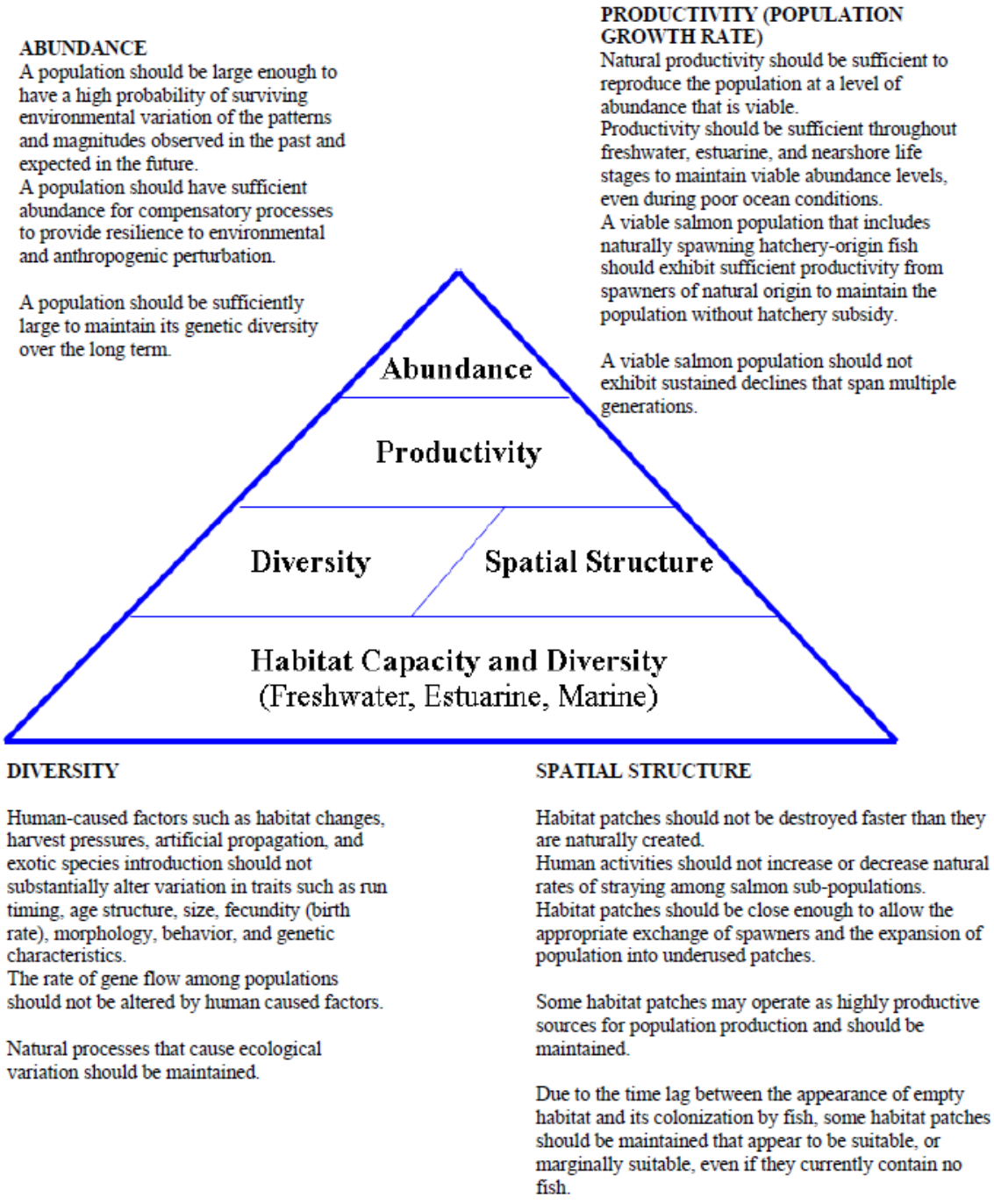


Figure 4. Viable Salmonid Population parameters and their attributes.

Source: (National Marine Fisheries Service 2014b)

The VSP concept also identifies guidelines describing a viable ESU/DPS. The viability of an ESU or DPS depends on the number of populations within the ESU or DPS, their individual status, their spatial arrangement with respect to each other and to sources of potential catastrophes, and diversity of the populations and their habitat (Lindley et al. 2004). General guidelines describing what constitutes a viable ESU are presented in (McElhany et al. 2000), while more specific recommendations of the characteristics describing a viable Central Valley salmonid population are found in Table 1 of Lindley et al. (2007).

During the initial steps taken to assess the individual fish response to the proposed action by assessing frequency of exposure, the proportion of the population affected, and the severity of the stressor, in order to determine the magnitude of the effect. Changes in these individual characteristics are understood to influence the fish population dynamic rate functions of growth, recruitment, and mortality (Ricker 1975, Stearns 1992). Growth information is used to assess the health of an individual, the population, and the environment (Birkeland and Dayton 2005, Quist et al. 2012). Annual and interannual recruitment variability is the primary driver of the productivity of a population and may be used to predict future changes in the age structure of the population (Winemiller 2005). Likewise, understanding sources of mortality is important for managing NMFS-trust resources and actions that affect habitat. Together, these rate functions may be used to identify problems in a population, possible management actions, and responses to those actions (Rowell et al. 2008). During this individual fish response analysis, we examine the best scientific and commercial data available to determine if an individual's response to the effect of an action on the environment is likely to have a discernible effect on the individuals.

The ESA section 7 consultation process requires assessment of the effects of several stressors to the species. NMFS closely considered the conceptual models of the Delta Regional Ecosystem Restoration Implementation Plan (DRERIP, Williams 2010), the SAIL for sturgeon (Heublein et al. 2017) and salmonids (Johnson et al. 2017, Windell et al. 2017), and the Sacramento River Science Partnership (SRSP) Egg-to-Fry Value of Information Interim Report (Sacramento River Science Partnership 2023) when identifying and evaluating the importance, understanding, predictability, and availability of data related to effects of the proposed action. These types of conceptual models are particularly useful in that they identify the relative geographic region and the corresponding salmonid life stage affected within each region (Figure 5).

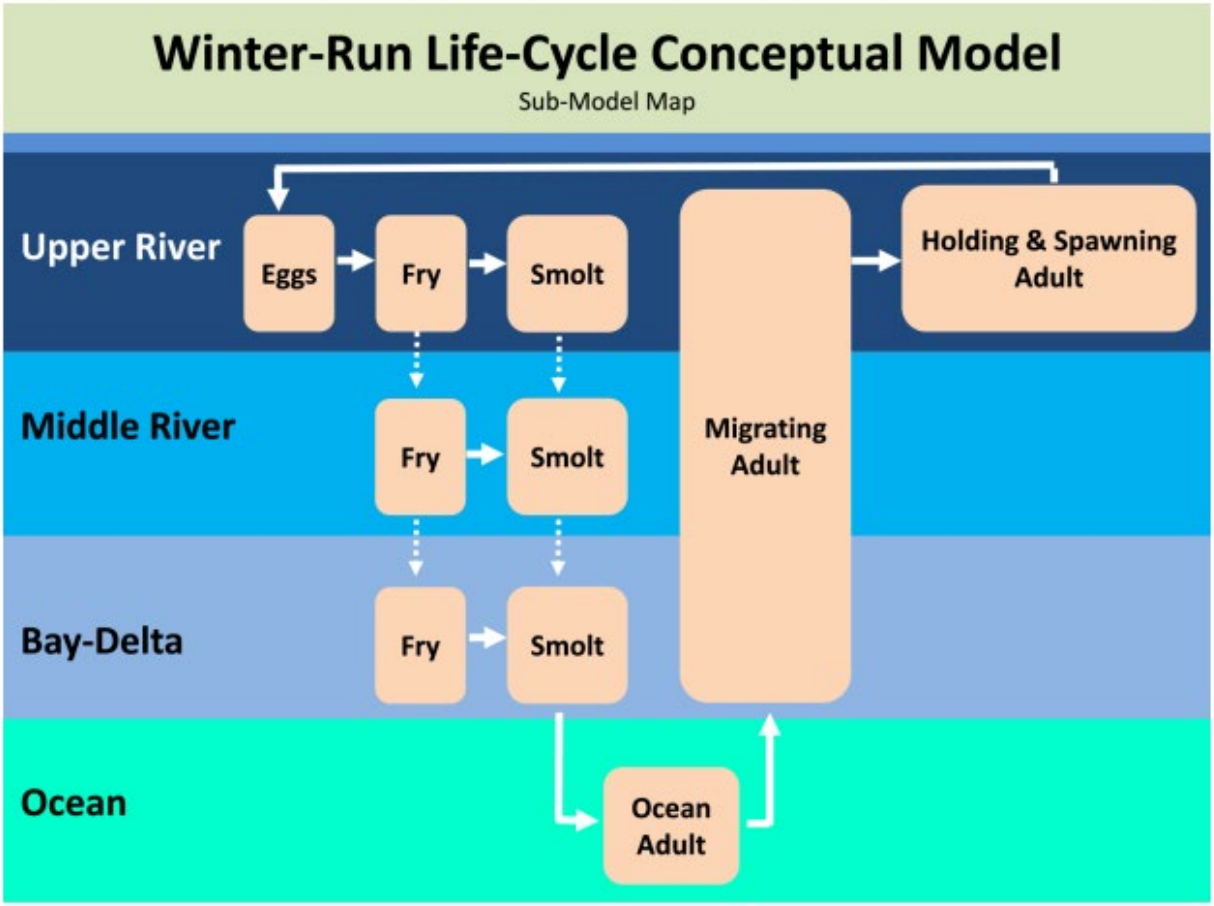


Figure 5. Graphic representation of the different life stages and geographic regions developed into sub-models for Sacramento River winter-run Chinook salmon. Solid arrows represent life stage transitions, and broken arrows represent movement into different geographic domains.

Source: (Johnson et al. 2017)

For the SAIL models, the geographic region is further described by hierarchical tiers that in turn describe the level at which a stressor will occur and the effect pathways from landscape attributes, environmental drivers, and habitat attributes to fish responses (e.g., Figure 6). The hierarchical tiers are described as follows:

- **Landscape Attributes:** Local to system-wide features that change slowly over long periods of time and directly influence environmental drivers.
- **Environmental Drivers:** Features that occur over a broad range of temporal and spatial scales and occur within the geographic range of the species. Environmental drivers directly influence habitat attributes.
- **Habitat Attributes:** Features that also have a broad range of spatial and temporal scale, but directly affect the species' demographic responses.

- **Fish Responses:** Factors associated with the transition to a subsequent life stage (i.e., life stage input, survival, timing and migration, and condition and growth). Fish responses are directly influenced by habitat attributes.

Management actions are noted with a yellow star within the geographic region conceptual model, and where specific stressors are determined to be under direct management control and can act on factors in any of the tiers to influence a fish response. The conceptual models describing these stressors and their effects are reflected in the structure and evaluations of the effects analysis.

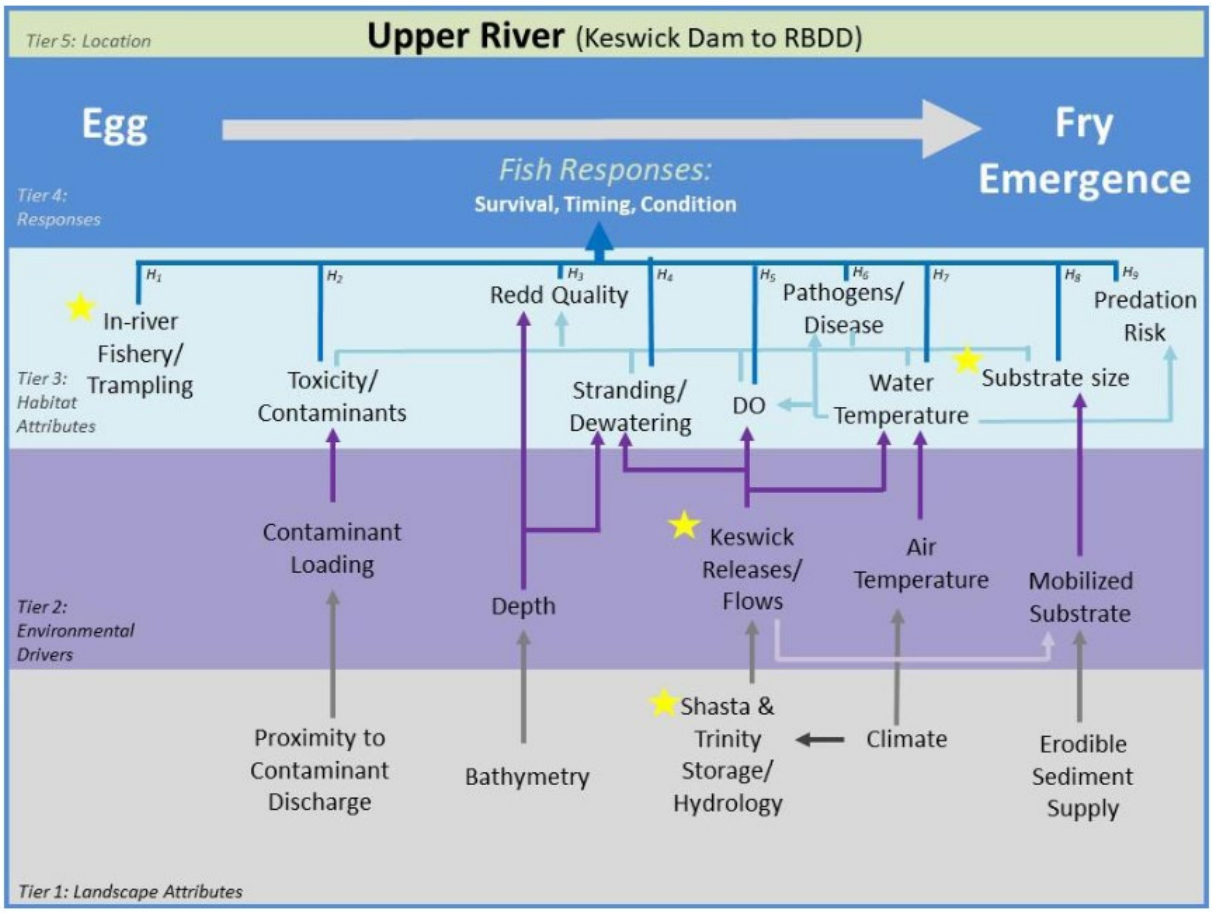


Figure 6. Conceptual model of drivers affecting the transition of Sacramento River winter-run Chinook salmon from egg to fry emergence in the Upper Sacramento River. Potential management actions are denoted by stars and described in the source document.

Source: (Windell et al. 2017)

We categorize the effects to individuals on the basis of the severity of the predicted response and resulting consequence in terms of the fitness of individuals. We use the term "fitness" to describe how we expect the exposure of individuals to certain stressors will affect their ability to survive. Table 4 outlines the basic set of information we evaluated.

Table 4. Example of information used to identify effects of the components of the proposed action to listed species.

Stressor	Life Stage (Location)	Life Stage Timing (Work Window Intersection)	Individual Response and Rationale of Effect	Severity of Stressor	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence

As Table 4 shows, for each response to an action, we assign a relative magnitude of effect (high, medium, or low). This is a qualitative assessment of the likelihood of a consequence occurring that allows for incorporation of some aspects of uncertainty (for instance, an infrequent but documented presence of a small number of individuals at a particular time is considered to have a "low" magnitude of effect). Specifically, the magnitude of effect is based on an assessment of the severity or level of benefit of the stressor, the proportion of the population exposed, and the frequency of exposure. Severity is categorized as lethal, sublethal, or minor; the level of benefit categories are high, medium, and low, where a high benefit addresses one or more lethal stressors such that individual survival is expected to increase. Medium benefit addresses one or more sublethal stressors such that individuals are expected to experience some increase in condition, but no change in survival is expected. Low benefit addresses one or more minor stressors, but it is not obvious that individuals would gain in condition. The proportion of the population exposed is characterized as a large proportion (70 percent or more of a population exposed), medium proportion (more than 2 percent, but less than 70 percent), or small proportion (exposure less than or equal to 2 percent). These categories of exposure are based on expert opinion and used to estimate the measure of exposure so that we may aggregate and compare those exposures across different watersheds and life stages, reflecting the differing levels of species monitoring and understanding. We also note that this approach to categorizing exposure includes intra-annual exposure of a population to the same stressor (i.e., exposure of the same cohort to a stressor multiple times in a year). The frequency of exposure is categorized as high (very frequent; occurring in more than 75 percent of years), medium (moderately frequent; occurring in 25 to 75 percent of years), and low (infrequent; occurring in fewer than 25 percent of years). Table 5 shows combinations of severity, proportion, and frequency that result in the various magnitudes of effect.

Table 5. Categories of effect magnitude.

A - Severity of Stressor (Lethal/Sublethal/Minor); Or Level of Individual Benefit for Conservation Measures (High/Medium/Low)	B - Proportion of Population Exposed (Large/Medium/Small)	C - Frequency of Exposure (High/Medium/Low)	Resulting Magnitude of Effect – Combination of A, B, and C
Lethal Stressor; High	Large or Medium	High, Medium, or Low	High
Sublethal; Medium	Large	High	High
Lethal; High	Small	High or Medium	Medium
Sublethal; Medium	Large	Medium or Low	Medium
Sublethal; Medium	Medium	High or Medium	Medium
Sublethal; Medium	Small	High	Medium
Minor; Low	Large	High or Medium	Medium
Minor; Low	Medium	High	Medium
Lethal Stressor; High	Small	Low	Low
Sublethal; Medium	Medium	Low	Low

A - Severity of Stressor (Lethal/Sublethal/Minor); Or Level of Individual Benefit for Conservation Measures (High/Medium/Low)	B - Proportion of Population Exposed (Large/Medium/Small)	C - Frequency of Exposure (High/Medium/Low)	Resulting Magnitude of Effect – Combination of A, B, and C
Sublethal; Medium	Small	Medium or Low	Low
Minor; Low	Small	Low	Low
Minor; Low	Medium or Small	Medium or Low	Low
Minor; Low	Small	High, Medium, or Low	Low

To characterize the "weight of evidence" for stressor effect identified in Table 5 we use an approach similar to that which has been employed by the DRERIP and SRSP reports (Williams 2010, Sacramento River Science Partnership 2023) where the relative importance, understanding, predictability and data availability related to each stressor effect is considered. This approach helps to ensure that the effects analysis is based on the best available scientific information and is categorized based on the characteristics of the analytical method, with modifications to include statistical power of analytical methods. Weights are defined as follows:

- **High:** Supported by multiple scientific and technical publications, especially if conducted on the species within the area of effect, quantitative data, and/or modeled results; high power in interpretation of analytical results
- **Medium:** Evidence between high and low definitions
- **Low:** One study, or unpublished data, or scientific hypotheses that have been articulated but not tested; low power in interpretation of analytical results

Once the individual exposure assessment is complete and the effects of the action are summarized with a relative magnitude of effect, we are able to aggregate effects and assess the effects by life stage and population. Where individuals are expected to experience either an adverse or beneficial consequence, we expect those consequences may also affect the population abundance or rates of reproduction or growth rates (or to increase the variance in these rates, Stearns 1992). A change in one or more of these variables is a necessary condition to affect one of the four VSP parameters of the population, which is in turn a necessary condition for change in a species' extinction risk or viability. If we determine that listed individuals are likely to

experience an adverse or beneficial consequence, we evaluate if those consequences may affect the viability of the populations those individuals represent, or to affect the likelihood of survival and recovery of those populations. This can be measured using changes in population abundance, reproduction rate, diversity, spatial structure and connectivity, growth rate, or variances in these metrics (Johnson et al. 2017, Yamane et al. 2018).

An inherent part of this step of the assessment is a consideration of the life cycle of the species. The consequences on a population's probability of extinction as a result of impacts to different life stages are assessed within this framework and are consistent with our current knowledge of the transition rates between life stages, the sensitivity of population growth to changes in those rates, and the uncertainty in the available estimates or information. An example of a Pacific salmonid life cycle is provided in Figure 7, which shows the cycle of the adult freshwater spawning, egg incubation and fry emergence, juvenile smoltification and migration, ocean residence, and adult migration and holding. Though not identical, the life history of green sturgeon is similar (i.e., spawning in upstream freshwater locations, juvenile migration through the riverine and estuarine areas, long ocean residence before returning to upstream spawning areas), and we take a similar approach in analyzing effects to both salmonids and sturgeon.

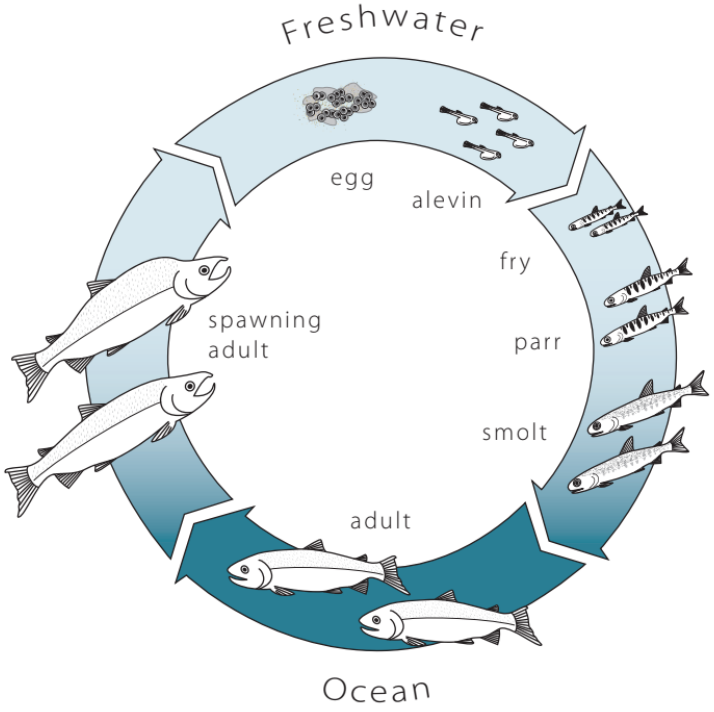


Figure 7. Conceptual diagram of the life cycle of a Pacific salmonid.

Source: (National Marine Fisheries Service 2016e)

Various sets of data and modeling efforts are useful to consider when evaluating the transition rates between life stages and consequences on population growth as a result of variations in those rates. These data are not available for all species considered in this opinion; however, data from surrogate species may be available for inference. Where available, information on transition rates, sensitivity of population growth rate to changes in these rates, and the relative importance of impacts to different life stages is used to inform the translation of individual effects to population-level effects. We recognize that populations may be vulnerable to small changes in relative rate of life stage transition such that even small reductions across multiple life stages can be sufficient to reduce the viability of a population.

In addition to the four VSP parameters, the quality, quantity, and diversity of the habitat (habitat capacity and diversity) available to the population in each of its three main habitat types (freshwater, estuarine, and marine environments) is critical to salmonid survival and recovery in the wild. Salmonids cannot persist in the wild and withstand natural environmental variations in limited or degraded habitats. Therefore, the condition and capacity of the ecosystem upon which the population (and species) depends play a critical role in the viability of the population or species. Without sufficient space, including accessible and diverse areas the species can utilize to weather variation in their environment, the population and species cannot be resilient to chance environmental variations and localized catastrophes. Salmonids have evolved a wide variety of life history strategies designed to take advantage of varying environmental conditions. Loss or impairment of the species' ability to use these adaptations increases their risk of extinction.

Recent research shows that a diversity of life histories in and among populations contributes to the maintenance of multiple and diverse salmonid stocks fluctuating independently of each other, which in turn reduces species extinction risk and long-term variation in regional abundances (Hilborn et al. 2003, Schindler et al. 2010, Yates et al. 2012, Satterthwaite and Carlson 2015). Such variance buffering of complex ecological systems has been described as a portfolio effect (Schindler et al. 2010), borrowing on concepts from financial portfolio theory (Markowitz 1952, Koellner and Schmitz 2006, Satterthwaite and Carlson 2015).

California's Central Valley salmon portfolio has weakened over time (Carlson et al. 2011, Herbold et al. 2018). The foundation for this "portfolio effect" of spreading risk across populations can be found at the within-population scale (Bolnick et al. 2011). For example, juvenile Chinook salmon leave their natal rivers at different sizes, ages, and times of the year, and this life history variation is believed to contribute to population resilience (Beechie et al. 2006, Lindley et al. 2009, Miller et al. 2010, Satterthwaite et al. 2014, Sturrock et al. 2015). Life history diversity promotes salmonid population resiliency, thereby reducing a species' extinction risk. Thus, preserving and restoring life history diversity is an integral goal of many salmonid conservation programs (Ruckelshaus et al. 2002). It is increasingly recognized that strengthening a salmon population's resilience to environmental variability (including climate change) will require expanding habitat opportunities to allow a population to express and maintain its full suite of life history strategies (Bottom et al. 2011, Herbold et al. 2018, Munsch et al. 2019).

3.4.1.2. Approach Specific to Southern Resident Killer Whales

The Overview of the Approach and Conceptual Models (Section 3.4) and Application of the Approach to Listed Species Analysis (Section 3.4.1) described above also apply to NMFS' approach for SRKWs. The SRKW DPS is a single population. The population is composed of

three pods, or groups of related matrilines, that belong to one clan of a common but older maternal heritage (National Marine Fisheries Service 2008d). The SRKW population is sufficiently small that the relative fitness of all individuals from each pod can influence the survival and recovery of the DPS. SRKWs are known to prefer Chinook salmon as their primary prey (Ford and Ellis 2006, Hanson et al. 2010b, Hanson et al. 2021), and SRKW population dynamics have previously been correlated with the abundance of Chinook populations over a broad scale throughout their range (Ward et al. 2013). Section 3.4.1.1 above discusses the analytical approach to assessing impacts to ESA-listed Chinook salmon. Similarly, an accompanying analysis of impacts to non-ESA-listed Chinook salmon (i.e., fall- and late fall-run Chinook salmon) will be performed to support assessment of effects on SRKW prey base. This analysis of effects to SRKWs relies on the expected impacts of the proposed action on the abundance and availability of Chinook salmon for prey and how any expected changes in prey availability will affect the fitness, and ultimately the abundance, reproduction, and distribution, of the SRKW DPS. To determine the magnitude of the effects of any expected change in prey availability on SRKWs, we consider several factors including the degree of impacts to salmon, timing of impacts to salmon, the life stage of salmon impacted, the degree of geographic overlap with SRKWs, and any conservation measures to reduce impacts and avoid high risk conditions.

3.4.2. Application of the Approach to Critical Habitat Analyses

The basis of the destruction or adverse modification analysis is to evaluate whether a proposed action affects the quantity or quality of the PBFs in the designated critical habitat for a listed species and, especially in the case of unoccupied habitat, whether a proposed action has any impacts to the critical habitat itself that would lead to the destruction or adverse modification of critical habitat. Following the steps in the conceptual model (Figure 2), NMFS will conclude that a proposed action is likely to destroy or adversely modify the designated critical habitat for the ESU/DPS if the action results in a direct or indirect alteration that appreciably diminishes the value of critical habitat for the conservation of a listed species. Such alterations may include, but are not limited to, those that alter the PBFs essential to the conservation of a species or that preclude or significantly delay development of such features (50 CFR 402.02). NMFS bases critical habitat analysis on the affected areas and functions of critical habitat essential for the conservation of the species, not on how individuals of the species will respond to changes in habitat quantity and quality described in the effects analysis of this opinion. If an area encompassed in a critical habitat designation is likely to be exposed to the direct or indirect consequences of a proposed action on the natural environment, NMFS considers whether the PBFs are likely to respond to that exposure. In particular, NMFS is concerned about responses that are sufficient to reduce the quantity or quality of those PBFs or capacity of that habitat to develop those features over time.

The analysis of effects on critical habitat is based on the species effects analysis and is summarized as they relate to the PBFs of critical habitat. As effects on individual fish are intrinsically linked to what life stage is present at the time of the exposure and condition of the habitat to support that life stage, we use the species effects analysis conclusions (exposure-response-risk) as the foundation for our analysis of effects to critical habitat. For example, as effects of riparian removal on rearing juveniles are likely to result in reduced growth/survival, the effect on critical habitat would be described in terms of the PBFs affected for that life stage,

thereby resulting in degraded rearing habitat. Table 6 includes the collection of information used to evaluate the effects of components of the proposed action on critical habitat.

Table 6. Example of information used to identify effects of the components of the proposed action to critical habitat.

Action Component	Location of Effect	Physical and Biological Features Affected	Response and Rationale of Effect	Magnitude of Effect	Weight of Evidence	Expected Change in Physical and Biological Feature Supporting the Life History Needs of the Species

Ultimately, to conduct this analysis, NMFS follows the basic exposure-response-risk analytical steps described in Figure 2 and according to the information detailed in Table 6. This approach allows us to determine the expected consequences of the action on PBFs, sort or rank the magnitude of those consequences, and determine whether areas of critical habitat are exposed to additive effects of the proposed action and the environmental baseline. We recognize that the value of critical habitat for the conservation of the species is a dynamic property that changes over time in response to changes in land use patterns, climate (at several spatial scales), ecological processes, changes in the dynamics of biotic components of the habitat, etc., which are reflected in the environmental baseline. However, it is further acknowledged that for the reasons listed above, some areas of critical habitat might respond to an exposure when others do not. We also consider how the PBFs of designated critical habitat are likely to respond to any interactions with and synergisms between cumulative effects of pre-existing stressors and proposed stressors.

At the heart of the analysis is the basic premise that the value of an overall critical habitat designation for the conservation of the species is the sum of the values of the components that comprise the habitat. For example, the value of listed salmonid critical habitat for the conservation of the species is determined by the value of the watersheds or other areas that makeup the designated area. In turn, the value of the watersheds or other areas is based on the quantity or quality of PBFs of critical habitat or capacity of that habitat to develop those features over time in that area.

Therefore, reductions in the quantity or quality of any PBFs of critical habitat or capacity of that habitat to develop those features over time may reduce the value of the exposed area (e.g., watersheds) for the conservation of the species, which in turn may reduce the value of the overall critical habitat designation for the conservation of the species. There are, however, other considerations. We look at various factors to determine if the reduction in the quantity or quality of any PBFs of critical habitat or capacity of that habitat to develop those features over time would affect the value of the critical habitat for the conservation of the species. Examples of these factors include the following:

- The timing, duration, and magnitude of the reduction
- The permanent or temporary nature of the reduction

We use the current value for the conservation of the species of those areas of designated critical habitat that occur in the action area as our point of reference for our assessment of effects of the proposed action on designated critical habitat. For example, if the critical habitat in the action area has limited current value or potential value for the conservation of listed species, then that limited value is our point of reference for our assessment of the consequences of the effects of the proposed action on the value of the overall critical habitat designation for the conservation of the species. In addition, we must determine whether reductions in the value of critical habitat for the conservation of the species in the exposed area of critical habitat are likely to appreciably diminish the overall value of critical habitat for the conservation of the species. A proposed action could adversely affect critical habitat in an action area without appreciably diminishing the value of critical habitat for the conservation of the species.

3.4.3. Characterization of the Environmental Baseline

ESA regulations define the environmental baseline as "the past and present impacts of all federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process. The impacts to listed species or designated critical habitat from federal agency activities or existing federal agency facilities that are not within the agency's discretion to modify are part of the environmental baseline." (50 CFR 402.02).

In the Environmental Baseline section, we summarize the past and present impacts leading to the current status of the species in the action area, including the effects of CVP and SWP operations to date. The Environmental Baseline section also describes the exposure to non-project stressors that are expected to occur in the future (e.g., climate change) or extend into the future, affecting listed species and their critical habitats. The environmental baseline characterizes the effects of the combination of natural environmental variation, human impacts, including those associated with past and current operations of the CVP and SWP, and past habitat actions undertaken or completed in response to previous consultations on the CVP and SWP operations.

Implicit in this definition of environmental baseline is a need to anticipate future effects, including the future component of the environmental baseline. Future effects of federal projects that have undergone consultation and of contemporaneous state and private actions, as well as future changes due to environmental variations, are future components of the environmental baseline, to which effects of the proposed project are added in the Integration and Synthesis section. In accordance with NMFS guidance (NMFS Procedure 02-110-18), climate change is included along with environmental variations in order to best characterize the future condition that the species will encounter.

The analysis considers future effects of federal projects that have undergone consultation and of contemporaneous state and private actions, as well as future effects of climate change, along with the effects of the proposed project. Given the timeline of the proposed action and because it includes an ongoing action (i.e., ongoing delivery of water), we analyze the entire suite of project effects including the effects of the non-discretionary elements of the proposed action which are considered part of the environmental baseline. As presented in the BA, the proposed action

includes operations of the CVP and SWP including existing structures and non-discretionary operations that are part of the environmental baseline.

3.5. Evidence Available for the Analysis

The primary sources of initial project-related information were the BA for the Reinitiation of Consultation on the LTO of the CVP and SWP, multi-agency meetings with the action agency to discuss project details and clarifications, and supplemental notes and data files provided through May of 2024. However, to conduct the consultation analyses, NMFS considered current literature and published information to provide a foundation for the analysis and represent evidence or absence of adverse consequences. In addition to a thorough review of up-to-date literature and publications reflected in the references cited in individual sections, the following provides a list of resources that we considered in our analyses:

- Final rules listing the species in this opinion as threatened or endangered
- Final rules designating critical habitat for the CV salmon and steelhead species, sDPS of green sturgeon, and SRKW
- Final rule describing the use of surrogates in incidental take statements (80 FR 26832, May 5, 2015)
- Final rule defining destruction or adverse modification of critical habitat (81 FR 7214, February 11, 2016)
- Final rule defining PBFs as replacements for PCEs (81 FR 7414, February 11, 2016)
- 50 CFR 402.02, ESA section 7 implementing regulations (89 FR 24268, April 5, 2024)
- EPA Region 10 Guidance for Pacific Northwest State and Tribal Temperature Water Quality Standards
- 2024 5-Year Review: Summary and Evaluation of SR Winter-Run Chinook Salmon ESU
- 2016 5-Year Review: Summary and Evaluation of CV Spring-Run Chinook Salmon ESU
- 2016 5-Year Review: Summary and Evaluation of CCV Steelhead DPS
- 2020 5-Year Review: Summary and Evaluation of sDPS Green Sturgeon
- 2022 5-Year Review: Summary and Evaluation of Southern Resident Killer Whales
- NMFS' 2019 Biological Opinion on CVP and SWP operations
- 2014 NMFS Recovery Plan for CV Salmonids
- 2018 NMFS Recovery Plan for the sDPS of Green Sturgeon
- 2008 NMFS Recovery Plan for Southern Resident Killer Whales
- 2024 peer reviews of the NMFS draft biological opinion
- 2024 WIIN Act review of the NMFS draft biological opinion
- Annual reports from interagency operations groups (e.g., Sacramento River Temperature Task Group Annual Report of Activities, American River Group Annual Report of Activities, Stanislaus Operations Group Annual Report of Activities, etc.)
- Information included in Collaborative Science and AMP processes

3.5.1. Primary Analytical Models and Operational Scenarios Considered

The LTO BA includes a suite of models used in the analysis of the effects of the operations of the proposed action. NMFS used these model results along with results from additional analytical methods, together listed below, to quantify the consequence of the proposed action. Life cycle models, those models capable of integrating effects over multiple life stages and cohorts to derive a population or species effect, were also included in the BA submission by Reclamation.

NMFS did not develop new scenarios for analysis; that is, the BA included modeling of the following six scenarios:

- NAA, equivalent to current operations
- Exploratory 3 (EXP3), "Obligated Releases Scenario" (non-discretionary operations)
- Alternative 2 without VAs nor TUCP modeling (Alt2woTUCPwoVA or Alt2v1)
- Alternative 2 without VAs but with TUCPs considered (Alt2wTUCPwoVA)
- Alternative 2 with Delta CVP and SWP VAs but without TUCPs (Alt2woTUCPDeltaVA or Alt2v2)
- Alternative 2 with all VAs but without TUCPs (Alt2woTUCPAllVA or Alt2v3)

Not all tools were used to analyze impacts in all divisions (see the Summary of the Proposed Federal Action section), as some are only applicable to certain rivers, geographic areas, or species. Fundamental models used in this opinion include the following:

- CalSim 3: A hydrological planning scenario tool that provides monthly average flows for the entire SWP and CVP system based on a 100-year historical streamflow record (1922–2021), adjusted for the influence of land-use change and upstream flow regulation. The model assumes that facilities, land use, water supply contracts, and regulatory requirements are constant over this period, representing a fixed level of development (e.g., 2020, 2040). This approach is intended to represent the possible range of water supply conditions for the Central Valley.
- DSM2-HYDRO: One-dimensional mathematical hydrodynamic model for dynamic simulation of one-dimensional hydrodynamics, water quality, and particle tracking in a network of riverine or estuarine channels. The hydrodynamic module was used to predict flow rate, stage, and water velocity in the Delta and Suisun Marsh and used to support routing and hydrodynamic analyses.
- HEC-5Q: A computer model simulation developed by the Hydrologic Engineering Center (HEC) of flood control and conservation systems that includes water quality analysis, which has the unique capabilities to accept user-specified water quantity and quality needs system-wide and to decide how to regulate the network of reservoirs. The decision criteria are programmed to consider flood control, hydropower, instream flow (municipal, industrial, irrigation, water supply, fish habitat) and water quality requirements, using CalSim flow and climatic model output to predict monthly water temperature on the Trinity, Feather, American, and Stanislaus river basins and upstream reservoirs.
- Reclamation Egg Mortality Model/SacSalMort: Temperature-exposure mortality criteria for three life stages (pre-spawned eggs, fertilized eggs, and pre-emergent fry) are used along with the spawning distribution data and output from the river temperature models to compute percentage of salmon spawning losses; used in fall-run and late fall-run Chinook salmon analysis in evaluation of SRKW prey base.
- Delta Passage Model (DPM): Simulates migration and mortality of Chinook salmon smolts entering the Delta from the Sacramento, Mokelumne, and San Joaquin rivers through a simplified Delta channel network, and provides quantitative estimates of relative Chinook salmon smolt survival through the Delta to Chipps Island.
- Enhanced Particle Tracking Model (ePTM): Model of buoyant particles with fish behavior applied to simulate migration pathways of juvenile fish. Developed by the

SWFSC and a component of the Sacramento River Winter-Run Chinook Salmon Life Cycle Model.

- ECO-PTM: Model of buoyant particles with drivers that estimates fish routing through Georgiana Slough, the Delta Cross Channel, the Sutter/Steamboat slough complex, or the Sacramento River.
- Interactive Object-oriented Simulation (IOS): A stochastic life cycle model for SR winter-run Chinook salmon in the Sacramento River (Zeug et al. 2012).
- Oncorhynchus Bayesian Analysis (OBAN): A statistical-based SR winter-run Chinook salmon life cycle model used to evaluate the effects of project operations.
- Salvage-Density Analysis: A model of entrainment into the South Delta facilities as a function of flow based on historical salvage data.
- Winter-Run Chinook Salmon Coded Wire Tag (CWT) Proportional Salvage Model: A model developed to estimate the fraction of juvenile SR winter-run Chinook salmon in the Delta predicted to be salvaged based on hydrologic conditions and fish size (Zeug and Cavallo 2014, Cavallo et al. 2015).
- NMFS SWFSC Temperature Dependent Egg Mortality Model (Martin et al. 2017): A temperature-dependent mortality (TDM) model for Chinook salmon embryos that accounts for the effect of flow and dissolved oxygen on the thermal tolerance of developing eggs.
- Anderson Egg Mortality Model: Models for managing the Sacramento River temperature during the incubation of SR winter-run Chinook salmon which characterize temperature- and density-dependent mortality from egg through fry survival.
- Winter-Run Chinook Salmon Life Cycle Model (WRLCM): A state-space and spatially explicit life cycle model of SR winter-run Chinook salmon eggs, fry, smolts, juveniles in the ocean, and mature adults that includes density-dependent movement among habitats.
- Floodplain Inundation: Analysis of flow results to determine suitable area based on floodplain hydraulic modeling studies that informed relationships between floodplain flow and suitable area.
- Sacramento River Redd Dewatering and Juvenile Stranding Analysis: The percentage of redds or likely juveniles in the Sacramento River lost to dewatering or stranding estimated using USFWS (2006) tables that relate spawning and dewatering flows to percent reductions in species- or race-specific spawning and rearing habitat.
- Flow Threshold Survival Model: A flow threshold model used to assess potential effects of changes in flow in the Upper Sacramento River on juvenile Chinook salmon as a result of flow-survival relationships described by Michel et al. (2021).
- SacPAS Fish Migration Model: This model is a reconfiguration for the Sacramento River of the NMFS Comprehensive Passage (COMPASS) smolt passage model, developed for Columbia River salmon and steelhead (Zabel et al. 2008).
- STARS Model (Perry et al. 2019): Survival, Travel Time, and Routing Simulation model developed by the United States Geological Survey (USGS). A stochastic, individual based simulation model designed to predict survival of a cohort of a fish that experiences variable daily river flows as they migrate through the Delta.
- Juvenile Production Index (JPI) Model: The JPI Model considered a limited suite of variables that influence the number of SR winter-run Chinook salmon juveniles that pass RBDD (i.e. "fry-equivalents"). Model selection found that the number of female spawners and mean flow at Bend Bridge to be the best predictors of the JPI. Although

model documentation notes that July through September temperatures were significantly influential, temperature was not included in the final model. The JPI Model was used in Reclamation's National Environmental Policy Act (NEPA) analyses but was not a line of evidence that we included in the opinion. Regardless, we believe that future collaborative work on the JPI model through the WRAP is a logical next step for evaluating its potential application as an analytical or decision support tool.

Figure 8 provides a schematic of how the models relate to each other in terms of information flow. Because the CalSim 3 modeling characterized a median 2022 climate scenario +/- 15 years, that climate condition is represented in all "downstream" modeling that used the CalSim 3 results.

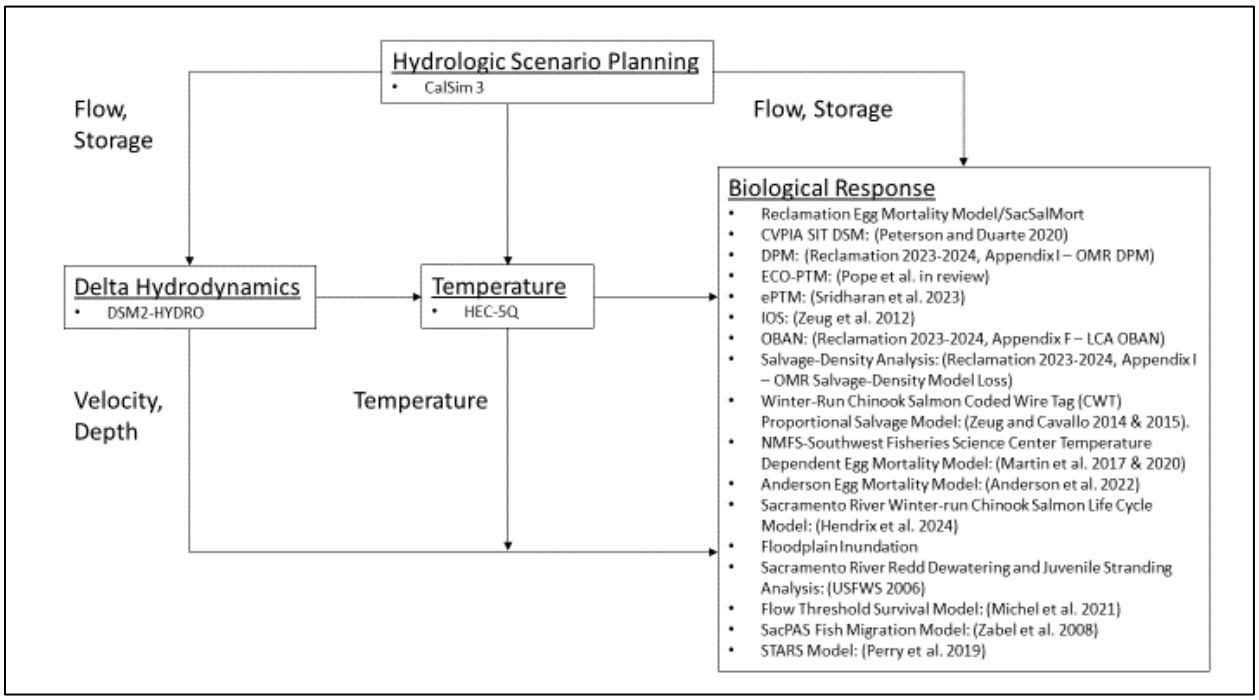


Figure 8. Main models used in the analysis of operations in the biological opinion and the flow of information with respect to the modeling output necessary run subsequent models.

NMFS notes that several of these "downstream" models have not been updated or recalibrated to include recent field observations, especially that of the most recent drought (2020–2022). While this may introduce an additional component of uncertainty in their application, the tools represent the best available scientific information for use in this analysis. Given that the CalSim 3 modeling includes a 100-year sample set of hydrologies up to and including 2021, we expect that the "downstream" models are likely to capture the effects of the majority of water year types.

Based on recommendations from various peer-reviews (Cummins et al. 2008, Anderson et al. 2009, National Research Council 2010, Rose et al. 2011), NMFS developed a life cycle modeling framework for CV Chinook salmon that is used in this opinion to allow better evaluation of how complex and interacting management actions affect salmon populations. Specifically, the analyses include results from a model framework developed by the NMFS SWFSC to describe salmon population dynamics given water management, habitat restoration, and climate change scenarios (Hendrix et al. 2024). The framework relies upon standard Central Valley physical (i.e., CalSim 3, DSM2, HEC-RAS) and chemical (i.e., temperature models, DSM2-QUAL) models to provide a characterization of abiotic conditions for a given scenario. A stage-structured population dynamics model of Chinook salmon links the habitat information to density-dependent stage transitions. These transitions describe the movement, survival, and reproduction that drive the dynamics of salmon populations.

The physical models applied in the BA and relied upon in this opinion are generalized and simplified representations of a complex water resources system. The models are not predictive models of actual operations, and, therefore, the results cannot be considered as absolute and within a quantifiable confidence interval. For instance, CalSim 3 is a monthly planning model; it is not calibrated and cannot be used in a real-time predictive manner. CalSim 3 results are intended to be used in a comparative manner, which allows for assessing the changes in the CVP and SWP system operations and resulting incremental effects between two scenarios. This and any subsequent models that use CalSim 3 results require caution when used to characterize absolute conditions or conditions on a sub-monthly time step. Similarly, each of the analytical models have limitations to their application and interpretation, and we discuss these limitations in effects analysis sections where they are applied and incorporated into evaluation of effects.

Our analysis culminates in an aggregate assessment of the proposed action, considered with the environmental baseline and cumulative effects in the Integration and Synthesis section to draw conclusions. Therefore, we use the results of the analysis in the exposure-response-risk framework along with knowledge of the species status and environmental baseline to evaluate the overall conditions that fish experience. The quantitative results of the analytical methods are used to inform this evaluation as much as possible, though, given the limitations of many of the models to comparative analyses, this assessment does rely on a qualitative analysis and application of results.

3.5.2. Assumptions in the Analysis

To address the uncertainties identified above related to the proposed action and the analysis provided in the BA, NMFS used its professional judgment to establish a set of reasonable key assumptions required to address existing data gaps in the BA that are critical to our analysis of effects. General assumptions that were made in filling those data gaps include the following:

- Species presence data are an accurate description of when and where a proportion of a particular species can be expected to occur in a particular area. While real-time monitoring in any given year may provide an opportunity to fine-tune short-term presence information, the available data that characterize both the bulk of presence and the tails (that is, smaller proportion) of presence are considered the best information for informing exposure and risk.

- The characterization of future conditions incorporated into the proposed action and opinion analysis is applicable throughout operations until a subsequent consultation on the CVP and SWP is completed. The proposed action and opinion analyses characterize climate conditions, water demands, and build-out as predicted for approximately 2037.
- The project, as characterized in the modeling provided by the BA, does not simulate short-term real-time operations, especially those that are dependent on biological triggers. Because the modeling analysis is based on comparative long-term scenario planning tools, it is not able to emulate the daily operations that would be implemented to manage according to biological, water quality, and other constraints. NMFS has analyzed the effects of the project as characterized by an initial approach to operations as identified by the operational criteria of the proposed action and completed auxiliary analyses when possible to evaluate the effects of real-time operations that are within the operational criteria identified in the proposed action.
- Results that include confidence intervals to characterize uncertainty are viewed in totality, considering the range of results over the intervals and not simply mean or median values.
- This opinion uses regulatory and analytical surrogates when species-specific data or evidence are not available to inform the analysis. This may be in the form of surrogate species or habitat processes. We understand that the use of surrogates in the form of hatchery releases (e.g., late fall-run Chinook salmon to determine CV spring-run Chinook salmon behavior), different species (e.g., Chinook salmon to determine steelhead behavior; and other species of sturgeon to determine effects of contaminant exposures on green sturgeon), and even the same run and species (e.g., hatchery fish and laboratory studies to determine wild/natural fish behavior) may not predict or emulate the exact behavior of the species under analysis in its natural environment, or provide exact fish routing, timing, duration of migration, and export pumping entrainment patterns. However, when direct evidence or similar evaluations are not available for the species under analysis, we use data and results from surrogates with strong similarities in physiological needs, life history stages, and general behaviors. In the absence of data on salmonids and green sturgeon in the wild, NMFS considers these studies one of the best available sources of information used to determine the potential effects of CVP and SWP operations.
- For purposes of incidental take where the origin of runs of Chinook salmon or steelhead cannot be differentiated, uniquely-marked hatchery fish (surrogates) that are released at the same time, location, and size as the listed species may best represent the incidental take of that listed species. The use of surrogates for this purpose minimizes the amount and extent of take associated with tagging or capturing listed species to monitor take.
- If the VAs are incorporated into the SWRCB's Water Quality Control Plan and the VA parties execute the agreements, Reclamation will request subsequent consultation consistent with the framework programmatic consultation process and will include details about how coordinated operations will be implemented. If the SWRCB does not approve the VAs or the parties do not execute the agreements in order to implement the VAs, reinitiation of this consultation may be necessary.

Our analysis considered the limitations and assumptions of the analyses included in the LTO BA, described in the Delta Science Program's *Peer Review of the Fish and Aquatic Effects Analysis for the Long-Term Operations of the Central Valley Project and State Water Project*, (Rose et al. 2024). Some of these limitations, assumptions, and recommendations are summarized below:

- The reliance on monthly CalSim 3 output to assess biological effects of the proposed action is inadequate for fish species that respond to daily or finer time scales. Methods to add daily and finer variability to monthly averages, preserving the full distribution of sub-monthly variation, were not employed in the proposed action modeling.
- The proposed action effects analysis in the LTO BA lacked a clear approach to how the stressor by life stage results are aggregated and considered at the species level and for cross-species comparisons. This is needed to ensure a comprehensive analysis that accounts for the cumulative effects of multiple stressors and enables a better understanding of population-level outcomes.
- The statistical correlation models based on annual values that relate habitat to year-class indices may not accurately predict responses to new environmental and ecological conditions.
- Historical environmental drivers and physical data may be outdated. The ecosystem is dynamic, and using outdated data may not accurately reflect current relationships between biological effects and environmental variables.
- There is apparent insensitivity of some models to different alternatives. This may indicate that stressor differences among alternatives are being averaged away or underestimated.
- Climate change effects on model predictions are not quantified (e.g., simulations with and without climate change) particularly their potential dominance in driving responses to different alternatives.
- Species responses to stressors are limited to population abundance and trends. Factors such as spatial diversity, life history diversity, and the degree of reliance on hatcheries are needed in order to provide a more comprehensive assessment of species' conservation status.

Many of the methods described above focus the analyses on particular aspects of the action or affected species. Key to the overall assessment, however, is an integration of the effects of the proposed action with each other and with the baseline set of stressors to which the species and critical habitat are also exposed. In addition, the final steps of the analysis require a consideration of the effects of the action within the context of the baseline condition of the species and critical habitat. That is, following the hierarchical approaches outlined above, NMFS combines the effects of the action to determine whether the action is likely to appreciably reduce the likelihood of both the survival and recovery of the species or likely to result in the destruction or adverse modification of critical habitat. Because not all components of the proposed action were presented with the specificity required to analyze a particular outcome of effect, NMFS' determination is based on a collection of site-specific and framework-level action components. This can explain and result in different conclusions in the BA compared to the biological opinion.

3.6. Integrating the Effects

The Integration and Synthesis section is the final step in our assessment of the risk that the proposed action poses to species and critical habitat. In this section, we add the effects of the action (Section 7) to the environmental baseline (Section 6) and the cumulative effects (Section 8), taking into account the status of the species and critical habitat (Section 4), to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) appreciably diminishes the value of designated or proposed critical habitat for the conservation of the species. In this opinion, NMFS uses the VSP parameters of abundance, productivity, spatial structure, and diversity to represent the species' as surrogates for reproduction, numbers, or distribution.

3.7. Presentation of the Analysis in This Opinion

A "biological opinion is the document that states the opinion of the Service as to whether or not the federal action is likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of critical habitat" (50 CFR 402.02). Opinions are constructed around several basic sections that in many cases represent specific requirements placed on the analysis by the ESA and implementing regulations. These sections contain different portions of the overall analytical approach described here. This section is intended as a basic guide to the other sections of this opinion and the analyses that can be found in each section. Every step of the analytical approach described above is presented in this opinion in either detail or summary form.

Description of the Proposed Action—This section summarizes the proposed federal action. This description is the first step in the analysis where we consider the various elements of the action and determine the stressors expected to result from those elements. The nature, timing, duration, and location of those stressors help define the action area and provide the basis for our exposure analyses.

Rangewide Status of the Species and Critical Habitat—This section provides the baseline condition for the species and critical habitat at the listing and designation scale. For example, NMFS evaluates the current viability of each salmonid ESU/DPS given its exposure to human activities and natural phenomena such as variations in climate and ocean conditions, throughout its geographic distribution. These reference conditions form the basis for determining whether the proposed action is likely to jeopardize the continued existence of the species or result in the destruction or adverse modification of critical habitat. Other key analyses presented in this section include critical information on the biological and ecological requirements of the species and critical habitat and the impacts to species and critical habitat from existing stressors.

Environmental Baseline—This section provides the baseline condition for the species and critical habitat within the action area. By regulation, the environmental baseline includes the past and present impacts of all federal, state, or private actions and other human activities in the action area; the anticipated impacts of all proposed federal projects in the action area that have already undergone formal or early ESA section 7 consultation; the impact of state or private actions, which are contemporaneous with the consultation in process on the species and critical habitat; and the impacts from federal agency activities or existing federal agency facilities that

are not within the agency's discretion to modify. This section will also include anticipated effects of climate change on the species and critical habitat within the action area. In this opinion, some analysis may be contained within the Status of the Species and Critical Habitat section, due to the large size of the action area (which entirely or almost entirely encompasses the freshwater geographic ranges of some listed fish species). This information forms part of the foundation of our exposure, response, and risk analyses.

Effects of the Proposed Action—This section details the results of the exposure and response analyses for effects of the proposed action on individuals and proportion of the listed species population and PBFs and value for the conservation of the species of critical habitat within the action area. This will include the direct or indirect effects of an action on the species or critical habitat, together with the effects of other activities that will be added to the environmental baseline. Indirect effects are those that are caused by the proposed action and are later in time, but still are reasonably certain to occur. Discussion of results will include identification of uncertainties associated with analytical methods or interpretation and will highlight instances of application of the precautionary principle. In the case of the proposed action, climate change effects as modeled for a 2037 climate scenario will be incorporated into the analysis by explicit modeling and additional qualitative evaluations to better incorporate more recent climate projections.

Cumulative Effects—This section summarizes the impacts of future non-federal actions reasonably certain to occur within the action area, as required by regulation. Similar to the rest of the analysis, if cumulative effects are expected, NMFS determines the exposure and response of individuals of the species and features of critical habitat. Future federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

Integration and Synthesis of Effects—The integration and synthesis is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we add the effects of the action to the environmental baseline and the cumulative effects, taking into account the status of the species and critical habitat, to formulate NMFS' opinion as to whether the proposed action is likely to: (1) reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its reproduction, numbers, or distribution; or (2) appreciably diminish the value of designated critical habitat for the conservation of the species. Discussion will include identification of uncertainties associated with the integration of effects and will highlight instances of application of specific assumptions used to inform the analysis.

4. STATUS OF THE SPECIES AND CRITICAL HABITAT

This section provides a summary of the status of each ESA-listed species and designated critical habitat that would be affected by the proposed action. The status is determined by the level of extinction risk that the listed species face, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. This informs the species' likelihood of both survival and recovery. This species status section provides the species' current "reproduction, numbers, or distribution" as described in (83 FR 35178).

This section provides a summary of the condition of critical habitat throughout the designated area, summarizes the value of the various watersheds and coastal and marine environments that make up the designated area, and discusses the current function of the essential PBFs that form the value for the conservation of the species.

4.1. Sacramento River Winter-Run Chinook Salmon

4.1.1. Introduction and Background

The SR winter-run Chinook salmon ESU includes SR winter-run Chinook salmon spawning naturally in the Sacramento River and its tributaries, as well as SR winter-run Chinook salmon that are part of the conservation hatchery program at the LSNFH (70 FR 37204, June 28, 2005; Hatchery Listing Policy).

In 1989, NMFS listed SR winter-run Chinook salmon under the ESA and classified it as a threatened species (54 FR 32085, August 4, 1989; Table 7). This initial classification, as threatened, was reaffirmed in 1990 (55 FR 46515, November 5, 1990), but the species was subsequently uplisted to endangered in 1994 (59 FR 440, January 4, 1994).

Table 7. Summary of the listing history under the Endangered Species Act for the Sacramento River winter-run Chinook salmon Evolutionarily Significant Unit.

Salmonid Species	ESU/DPS Name	Original Listing	Revised Listing(s)
Chinook Salmon (*O. tshawytscha*)	Sacramento River winter-run Chinook salmon	**FR Notice:** 54 FR 32085 **Date:** August 4, 1989 **Classification:** Threatened (emergency interim rule)	**FR Notice:** 55 FR 12191 **Date:** April 2, 1990 **Re-affirmation:** Threatened (emergency interim rule) **FR notice:** 55 FR 46515 **Date listed:** November 5, 1990 **Classification**: Threatened **FR notice:** 59 FR 440 **Date:** January 4, 1994 **Re-classification**: Endangered **FR notice:** 70 FR 37160 **Date listed:** June 28, 2005 **Classification**: reaffirmed classification as Endangered

On July 22, 2014 (79 FR 42504), NMFS completed the Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-run Chinook Salmon and Central Valley Spring-run Chinook Salmon and the Distinct Population Segment of California Central Valley Steelhead (National Marine Fisheries Service 2014b). In the following (2016) 5-year review it was

recommended that the SR winter-run Chinook should remain listed as endangered (81 FR 33468, May 26, 2016, National Marine Fisheries Service 2016c). Likewise, on February 2, 2024, in the agency's most recent 5-year review for SR winter-run Chinook salmon, NMFS again concluded that the species should remain listed as endangered (National Marine Fisheries Service 2024a).

4.1.2. Life History

Sacramento River winter-run Chinook salmon are unique because they spawn during summer months when air temperatures usually achieve their yearly maximum. As a result, SR winter-run Chinook salmon require stream reaches with cold water sources that will protect embryos and juveniles from the warm ambient conditions in summer.

Adult SR winter-run Chinook salmon immigration and holding (upstream spawning migration) through the Delta and into the lower Sacramento River occurs from December through July, with a peak during the period extending from January through April (U.S. Fish and Wildlife Service 1995). Sacramento River winter-run Chinook salmon are sexually immature when upstream migration begins, and they must hold for several months in suitable habitat prior to spawning. Sacramento River winter-run Chinook salmon primarily spawn in the main stem Sacramento River between Keswick Dam (river mile 302) and the Red Bluff Diversion Dam (river mile 243). Spawning occurs between late-April and mid-August, with a peak in June and July as reported by CDFW annual carcass and redd surveys (Killam 2023). Sacramento River winter-run Chinook salmon embryo incubation in the Sacramento River can extend into October (Vogel and Marine 1991).

Sacramento River winter-run Chinook salmon fry rearing in the upper Sacramento River exhibit peak abundance during September, with fry and juvenile emigration past Red Bluff Diversion Dam primarily occurring from July through November (Poytress et al. 2014). Emigration of SR winter-run Chinook salmon juveniles past Knights Landing, which is located approximately 155.5 river miles downstream of the Red Bluff Diversion Dam, occurs between November and March, peaking in December, with some emigration continuing through May in certain years (Snider and Titus 2000, Roberts 2007).

4.1.3. Population Structure

In the previous 5-year review (National Marine Fisheries Service 2016c), NMFS defined the SR winter-run Chinook salmon ESU as being composed of all naturally spawned SR winter-run Chinook salmon originating from the Sacramento River and its tributaries, as well as SR winter-run Chinook salmon from the artificial propagation program at the LSNFH (70 FR 37160, June 28, 2005). The addition of the artificial propagation program to the ESU represents NMFS' determination that the artificially propagated stock is no more divergent relative to the local natural population than what would be expected between closely related natural populations within the ESU (70 FR 37204, June 28, 2005). This determination is supported by the fact that the source of fish for both the captive broodstock program and the supplementation program is local, natural-origin SR winter-run Chinook salmon from the Upper Sacramento River. Ultimately, the Hatchery Listing Policy helped to guide the NMFS analysis of whether individual hatchery programs should be included as part of the ESU and to support the 2020 Final Rule on Revisions to Hatchery Programs as Part of Pacific Salmon and Steelhead Species Listed under the Endangered Species Act (85 FR 81822, December 17, 2020).

In 2016, the description of the hatchery program at LSNFH was revised to add an additional captive broodstock component, which was restarted in 2015 after being implemented from 1991 to 2007 (85 FR 81822, December 17, 2020). Starting in 2017, efforts were initiated to establish a viable, self-sustaining, and locally adapted population of SR winter-run Chinook salmon in Battle Creek to add to the spatial diversity (i.e., spatial structure) and abundance of the SR winter-run Chinook salmon ESU (U.S. Fish and Wildlife Service 2020b). Although not an independently viable population yet, efforts are underway to restore the Battle Creek watershed and reintroduce salmon and steelhead to the historical habitats therein (ICF International 2016).

4.1.4. Viability Status and Trends

4.1.4.1. Spatial Structure and Diversity

Spatial structure and diversity are two of the four core parameters of the viability of salmonid populations and ESUs (McElhany et al. 2000). The lack of population redundancy in the SR winter-run Chinook salmon ESU is the primary factor contributing to its high extinction risk. The "jumpstart" of the Battle Creek reintroduction efforts initiated in 2017 marks a significant milestone towards the goal of establishing a second SR winter-run Chinook salmon population (ICF International 2016, U.S. Fish and Wildlife Service 2020b), a priority recovery action identified in the recovery plan (National Marine Fisheries Service 2014b). The most recent returns of 942, 167, 127, and 11 (2020–2023) adult SR winter-run Chinook salmon to Battle Creek are another indication that reintroduction efforts are beginning to take hold (Azat and Killam 2024).

Spatial structure also promotes life history diversity, which has been shown to improve the resilience of salmon populations (Schindler et al. 2010, Johnson et al. 2017). Diverse habitats provide variation in localized temperature and food resources, which influences growth and phenotypic diversity (size and timing of out-migration) in salmon populations. Recent work by Phillis et al. (2018) suggests that SR winter-run Chinook salmon may rely on more diverse rearing habitats than previously considered (58 FR 33212) In particular, this work identifies the influence of non-natal Sacramento River tributaries and the Delta on juvenile rearing and survival (Phillis et al. 2018).

During the previous, 4-year drought (2012–2016), LSNFH increased the number of adults used in the supplementation program from 120 (target) adults to 164, 388, 257, and 137 in 2013–2016, respectively (Table 8, Azat and Killam 2024). This expanded production resulted in a significant increase in the proportion of hatchery-reared fish that returned to spawn (greater than 80 percent) in 2017 and 2018. The numbers of natural-origin spawners in 2017 and 2018 were low (153 and 461 individuals, respectively), resulting in a significant increase in the relative contribution of LSNFH hatchery-origin fish and potential reduction in genetic diversity during years of poor environmental conditions and high in-river mortality. Hatchery collection of adults was again increased to 191, 298, 482, and 507 to address drought impacts in 2020–2022.

Table 8. Sacramento River winter-run Chinook salmon escapement 2013–2022.

Year	SVI WYT	In-River	LSNFH	Battle Creek	Total Sac System
Dec 2012 - Aug 2013	**Dry**	5,922	164	0	6,086
Dec 2013 - Aug 2014	**Critical**	2,627	388	0	3,015
Dec 2014 - Aug 2015	**Critical**	3,182	257	0	3,440
Dec 2015 - Aug 2016	**Below Normal**	1,411	137	0	1,549
Dec 2016 - Aug 2017	**Wet**	797	180	0	979
Dec 2017 - Aug 2018	**Below Normal**	2,458	180	1	2,639
Dec 2018 - Aug 2019	**Wet**	7,853	180	21	8,128
Dec 2019 - Aug 2020	**Dry**	6,199	191	942	7,428
Dec 2020 - Aug 2021	**Critical**	9,998	298	167	10,548
Dec 2021 - Aug 2022	**Critical**	5,443	482	127	6,067
Dec 2022 - Aug 2023	**Wet**	1,920	507	11	2,482

Source: (Azat and Killam 2024). SVI WYT = Sacramento Valley Index Water Year Type; LSNFH = Livingston Stone National Fish Hatchery.

The recent increase in hatchery influence emphasizes the reliance on hatchery production to prevent a precipitous decline in overall abundance. However, hatchery influence and the potential loss of genetic diversity described by the percentage of hatchery spawners over the last four generations was greater than 30 percent, placing the population at a high risk of extinction. The long-term influence of the hatchery over seven generations (i.e., 21 years) is now at 20 percent. More recently, the decrease in hatchery influence in the 2019 returns supported by the return of a larger number of natural-origin adults (run = 5,000 individuals) indicates a potential for naturally spawning SR winter-run Chinook salmon to rebuild during periods of favorable environmental conditions (Johnson et al. 2023b).

4.1.4.2. Abundance and Productivity

The abundance of the SR winter-run Chinook salmon ESU has declined during recent periods of unfavorable ocean conditions (2005–2006) and prolonged drought (2007–2009, 2012–2016, and 2020–2022), which have underscored the risk posed by catastrophic events to a species that is currently composed of a single population. Temperature conditions during egg development and fry emergence were less than protective for much of SR winter-run Chinook salmon freshwater rearing in 2014 and 2015, reaching lethal levels in both years. The egg-to-fry survival estimate for brood year 2014 is 5 percent, which is a significant departure from the average of 26.4 percent for brood years 2002–2012 measured at Red Bluff Diversion Dam (Poytress et al. 2014,

Johnson et al. 2017). Warm temperatures in both freshwater and ocean ecosystems likely contributed to the low numbers of natural-origin adults observed in 2017 and 2018. These 2 consecutive years of poor returns increased the vulnerability of the overall population. Despite the poor returns, water year 2017 was one of the wettest years on record and may have contributed to the high survival of SR winter-run Chinook salmon, including those returns observed in 2019 (Killam 2023).

In 2012, the Red Bluff Diversion Dam gates (river mile 243) were removed to provide unimpaired salmon passage year-round, an action recommended in the recovery plan (National Marine Fisheries Service 2014b). This modification also changed the ability to count SR winter-run Chinook salmon adults at the Red Bluff Diversion Dam fish ladders (Williams et al. 2016). Based on the estimates and counts provided in the CDFW escapement data (GrandTab, Azat and Killam 2024), SR winter-run Chinook salmon abundance has declined since 2006 with recent decadal lows of 795 in-river spawners in 2017 (Figure 9). Escapement improved in 2018–2021 such that both the current total population size (sum of last 3 years [2020–2022]; N: LSNFH = 971, Sacramento River = 21,640) and 3-year mean run sizes (N_e: LSNFH = 324, Sacramento River = 7,213) satisfy the low-risk abundance criterion (N > 2500 or N_e > 500).

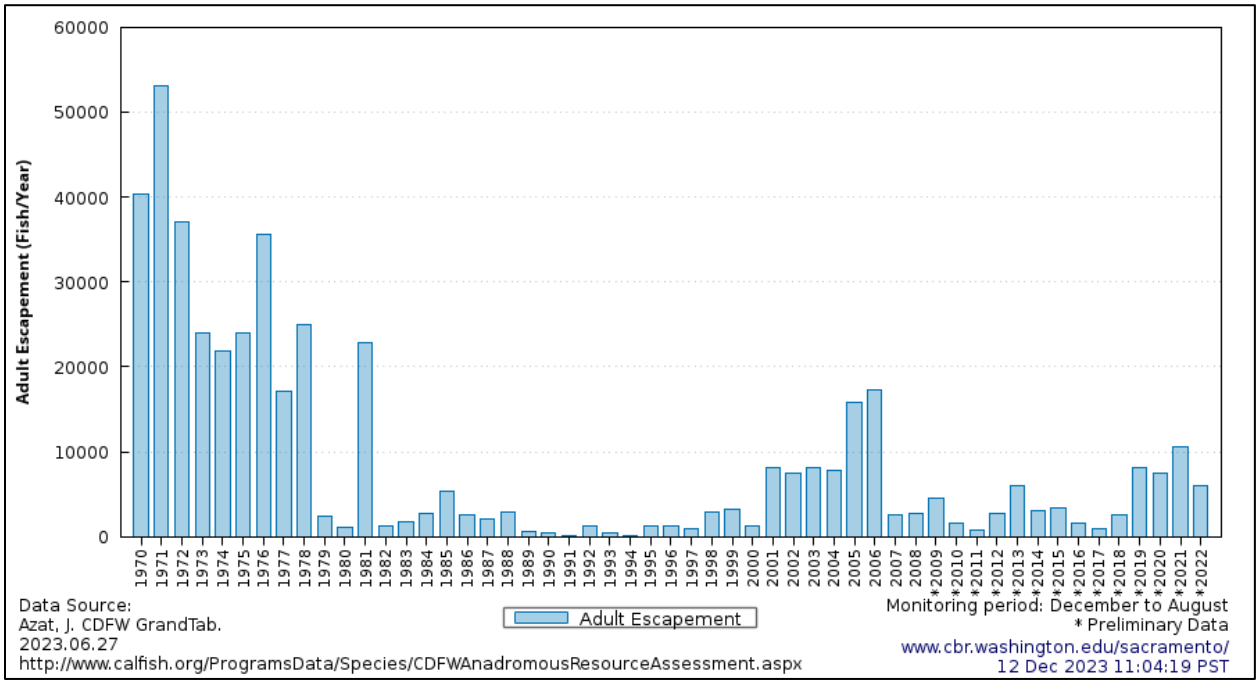


Figure 9. Sacramento River winter-run Chinook salmon annual adult escapement.

Source: SacPAS. Available at: https://www.cbr.washington.edu/sacramento/

The point estimate for the 10-year trend in 3-year mean run size is 3.28, suggesting a 3-fold increase in the 3-year average run size over the last 10 years, primarily bolstered by the relatively large escapement in 2019–2021 (average run size = 8,603; Figure 9). However, the recent maximum year-to-year decline in population size is 58.8 percent (2018). While the percent

decline does not exceed the catastrophic decline criteria (greater than 90-percent decline in one generation nor annual run size less than 500 spawners, Lindley et al. 2007), the 2012–2016 drought had a biologically significant effect on annual run sizes for natural-origin spawners in 2017 and 2018 (153 and 461 individuals, respectively) which would otherwise place the population at a moderate risk of extinction (Johnson et al. 2023b).

4.1.5. Recovery

Section 4(a)(1) of the ESA directs NMFS to determine whether any species is threatened or endangered because of any of the following five limiting factors: (a) the present or threatened destruction, modification, or curtailment of its habitat or range; (b) overutilization for commercial, recreational, scientific, or educational purposes; (c) disease or predation; (d) the inadequacy of existing regulatory mechanisms; or (e) other natural or man-made factors affecting its continued existence. Therefore, the status of each listing factor provides the necessary context for which to evaluate the potential effects of an action as they may relate to a particular threat to recovery.

The NMFS Recovery Plan for Central Valley Salmon and Steelhead (National Marine Fisheries Service 2014b) developed watershed classifications to assess the potential for populations to contribute to species recovery. There are three categories Core 1, Core 2, and Core 3. The NMFS Recovery Plan for Central Valley Salmon and Steelhead also identifies primary, candidate and non-candidate watersheds for reintroduction to historic habitats. Primarily reintroduction watersheds have the highest reintroduction priority.

- Core 1 populations meet or have the potential to meet the long-term objective of low extinction risk. These populations possess the known ability or potential ability to support a viable population.
- Core 2 populations meet or have the potential to meet the biological recovery criteria for moderate risk of extinction. These populations have lower potential to support viable populations due to lower abundance or amount and quality of habitat. They can contribute to increase diversity for a species and may provide resilience from catastrophic events that impact other populations.
- Core 3 populations are present in watersheds on an intermittent basis and require straying from other populations for their existence. They can contribute to increased diversity for a species and may provide resilience from catastrophic events that impact other populations.

The SR winter-run population in the Basalt and Porous Lava Diversity Group is the only Core 1 population in the ESU. Battle Creek and the McCloud River are described in the NMFS Recovery Plan for Salmon and Steelhead (National Marine Fisheries Service 2014b) as primary reintroduction watersheds for establishing new populations. There are no designated Core 2 or Core 3 populations of SR winter-run Chinook salmon.

4.1.5.1. The Present or Threatened Destruction, Modification, or Curtailment of Its Habitat or Range

Despite the recent number of habitat improvements, there remain major concerns related to SR winter-run Chinook salmon habitat. Primary among these concerns is the continued lack of

access to historical spawning habitats above Shasta and Keswick dams that relegate the species to a single spawning population below Keswick Dam (National Marine Fisheries Service 2014b) Likewise, the following threats remain an issue for the ESU's viability:

- Warm water temperatures and variable flows below Keswick Dam in the Upper Sacramento River, especially during drought and low storage conditions (National Marine Fisheries Service 2016c, 2019b)
- The relative lack and reduction of Central Valley floodplain/wetland rearing habitats in the Middle Sacramento River and Bay-Delta (Herbold et al. 2018)
- Water exports in the southern Bay-Delta affecting Delta hydrodynamics (San Francisco Estuary Partnership 2019) and potential for indirect mortality near the export facilities (National Marine Fisheries Service 2019b)
- Water quality concerns from point and nonpoint sources of contaminants[3] (Davis et al. 2018, Tian et al. 2021)

4.1.5.2. Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

The threat posed by overutilization for commercial, recreational, scientific, or educational purposes continues to be moderate to low. Because regulatory mechanisms designed to minimize the impacts of ocean harvest, freshwater angling, and scientific research on SR winter-run Chinook salmon are in place, overutilization is not considered a key factor limiting this ESU (National Marine Fisheries Service 2018b, Pacific Fishery Management Council 2023). Although scientific research impacts authorized through the WCR have increased for SR winter-run Chinook salmon in recent years (National Marine Fisheries Service 2024b), the reported number of individuals affected remains relatively small.

4.1.5.3. Disease or Predation

Disease and predation are persistent problems that continue to adversely affect SR winter-run Chinook salmon. Updated information from the USFWS and the LSNFH indicates that the threat of disease may only pose a significant risk to SR winter-run Chinook salmon in drought years where conditions such as low flows and high temperatures in the Sacramento River predominate (Lehman et al. 2020). And although there have been actions to understand and reduce predation, it remains unclear whether these actions have substantially decreased the overall level of predation throughout the Sacramento River and Delta. In addition to the threats of disease and predation, other related factors have emerged, such as invasive vegetation (Conrad et al. 2020) and chronic thiamine deficiency (Mantua et al. 2021), which are understood to negatively affect SR winter-run Chinook salmon survival. All of these factors are understood to be influenced by environmental conditions and are subject to a highly modified landscape and hydrology. Diseases like *C. Shasta* are more infectious during low flow warm water periods experienced during a drought. Submersed and floating aquatic vegetation are better adapted to the modified conditions of today's Delta, which in turn provides habitat for piscivorous fish species (Conrad et al. 2016).

[3] See also: EPA, ESA Workplan Update: Nontarget Species Mitigation for Registration Review and Other FIFRA Actions, Nov. 2022, https://www.epa.gov/system/files/documents/2022-11/esa-workplan-update.pdf

4.1.5.4. The Inadequacy of Existing Regulatory Mechanisms

Considering a relative improvement in a number of regulatory mechanisms which in turn provide additional protections for CV salmonids and/or their habitat, NMFS has concluded that the risk to the SR winter-run Chinook salmon ESU's persistence has improved. However, despite the recent improvement in the adequacy of regulatory mechanisms, there remain a number of concerns, including:

- The use of a baseline streamflow depletion condition for the California Sustainable Groundwater Management Act that is unlikely to provide adequate species or habitat protection (Zimmerman et al. 2018, Rhode et al. 2021)
- An imbalance in the suite of floodplain development incentives and disincentives that favor continued development and disconnection of the natural floodplain and riparian habitats (National Marine Fisheries Service 2008a, 2016c)
- A slowing positive trend, and sometimes a negative trend, in water quality and associated habitat condition (Spromberg et al. 2016)

4.1.5.5. Other Natural or Man-Made Factors Affecting Its Continued Existence

The most significant potential impacts to the species' persistence due other natural or man-made factors are those related to drought impacts and hatchery influence. Although complex and interrelated to many other stressors, the factors of drought and hatchery influence pose an increasing threat to the SR winter-run Chinook salmon ESU.

Historical precipitation and streamflow in the Sacramento River watershed are highly variable, with recent years 2017 and 2019 being wet water years, 2016 and 2018 being below normal years, and 2020, 2021 and 2022 being dry or critically dry.[4] Overall, rising atmospheric temperatures have exacerbated an already high evaporative demand in the region such that the region frequently experiences a significant moisture deficit. The moisture deficit results in low flow and warm water temperatures in the Sacramento River that in turn limits successful spawning, egg incubation, and fry development and emergence. Droughts also affect the broader landscape. Forests are already showing evidence of increased aridification in the form of forest fire severity and insect outbreak (Halofsky et al. 2020), which can have cascading effects on the aquatic environment.

Hatchery programs can affect naturally produced populations of salmon and steelhead in a variety of ways, including competition for spawning sites and food, predation effects, disease effects, genetic effects (e.g., outbreeding depression and hatchery-influenced selection), broodstock collection effects (e.g., effects to population diversity), and facility effects (e.g., water withdrawals and effluent discharge; National Marine Fisheries Service 2018b). And while expansion of hatchery production of SR winter-run Chinook salmon at LSNFH was necessary to address the poor in-river conditions experienced during recent droughts, these actions have continued to affect the ESU (e.g., increased hatchery influence). Despite the managed risk, recent actions implemented by the fish management agencies, such as restarting the captive broodstock

[4] DWR, California Cooperative Snow Surveys. Chronological Reconstructed Sacramento and San Joaquin Valley Water Year Hydrologic Classification Indice, available at: https://cdec.water.ca.gov/reportapp/javareports?name=WSIHIST

program at LSNFH, have presented new opportunities to improve the status of the ESU. For example, the Battle Creek Jumpstart Project commenced in 2017 using the progeny of captive broodstock at LSNFH (U.S. Fish and Wildlife Service 2018). This early implementation of actions related to the reintroduction of SR winter-run Chinook salmon to Battle Creek has and will continue to provide data that can be used to inform the formal reintroduction program, as described in the Reintroduction Plan (ICF International 2016).

4.1.6. Climate Change

Crozier et al. (2019) conducted a recent assessment of climate change vulnerability for Pacific salmon species where it was found that several factors contribute to the overall ranking of the SR winter-run Chinook salmon ESU as "very highly vulnerable" to climate change (Figure 10). The poor population viability of this single population spawning outside of its historical range was the greatest risk, as the ESU is not thriving under current climate conditions which are expected to worsen. The SR winter-run Chinook salmon ESU was found to be sensitive to hydrologic regime changes, increases in stream temperature, and summer water deficits, such that the ESU is vulnerable to cumulative life cycle impacts over multiple life stages. Juveniles are also vulnerable to changes in flooding, as decreased stream flows and incidents of flooding may limit their ability to use productive floodplain habitat for rearing. Sea level rise is also expected to reduce the availability of tidal marsh habitats for rearing juveniles.

The marine stage of SR winter-run Chinook salmon was ranked moderately vulnerable to climate impacts, with a high risk of exposure to changes in upwelling because of the unique migratory behavior of the ESU. These fish enter the ocean earlier than other Central Valley Chinook salmon, and have a more southerly and nearshore marine distribution compared to other Central Valley ESUs. This contracted range may make the ESU more vulnerable to localized upwelling conditions compared to other Pacific salmon.

Sacramento River winter-run Chinook salmon were ranked low in overall adaptive capacity because they are in the southernmost region of the range of Chinook salmon on the West Coast, and the California Central Valley offers the fewest opportunities for adaptive capacity of the Chinook salmon recovery domains. The limited phenotypic and genetic diversity remaining in the extant population is also likely to limit this ESU's ability to adapt to future climate change (Crozier et al. 2019).

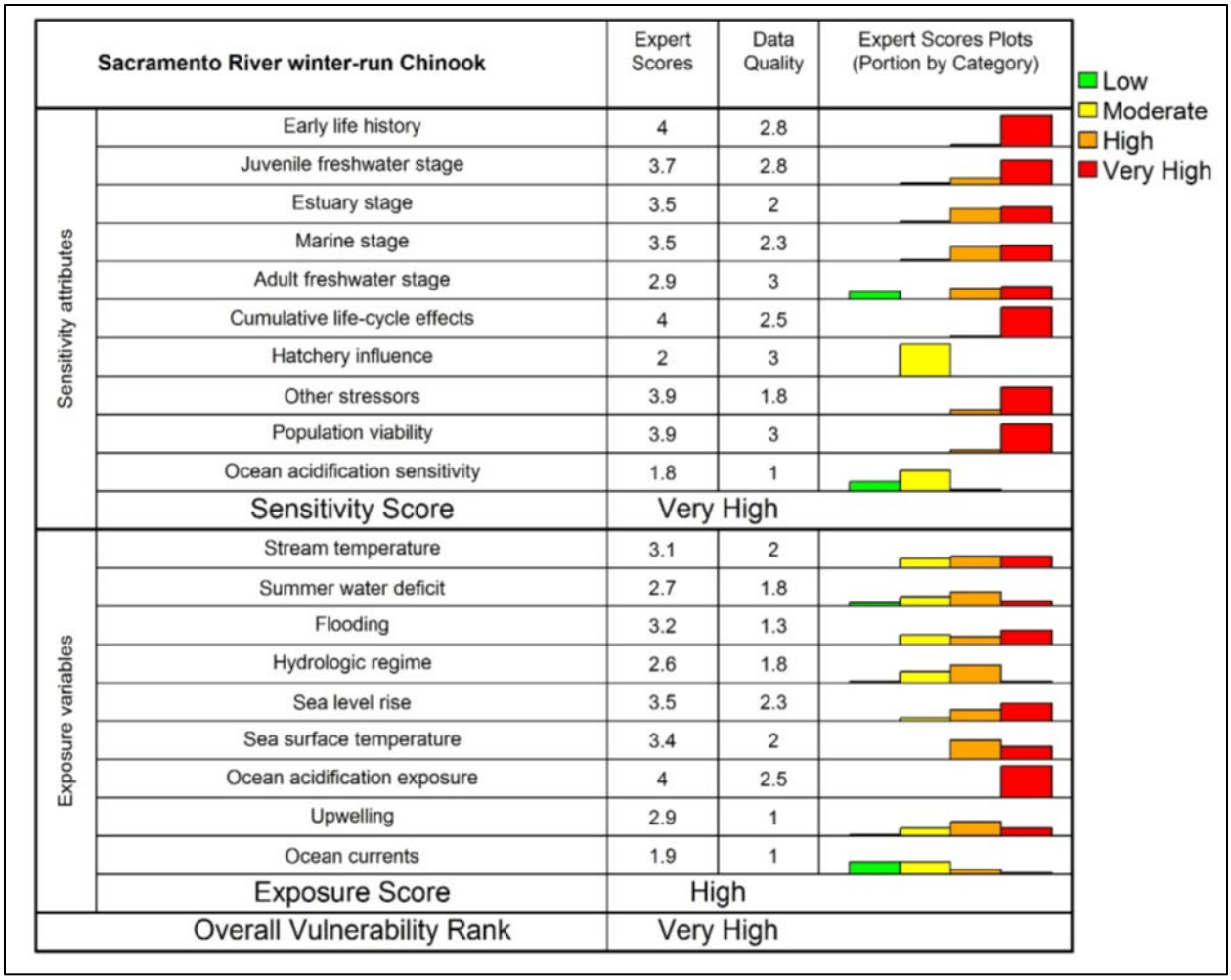


Figure 10. Sacramento River winter-run Chinook salmon Climate Effects Exposure and Vulnerability.

Source: (Crozier et al. 2019)

4.1.7. Summary

Overall, the SR winter-run Chinook salmon ESU remains at a high risk of extinction. Although abundance and productivity have shown modest improvement in the most recent years, the full effects of the 2020–2022 drought have yet to be realized due to the 3-year life cycle of the species. Meanwhile, the spatial structure of the ESU remains limited to the single population found in the main stem Sacramento River, and the genetic and life history diversity of the ESU may have been negatively affected by the increased hatchery production implemented to address drought conditions. The ESU also continues to face threats from disease; predation; habitat loss, alteration, and degradation; and is particularly susceptible to climate change and drought (National Marine Fisheries Service 2024a).

4.2. Designated Critical Habitat for Sacramento River Winter-Run Chinook Salmon

Critical habitat for SR winter-run Chinook salmon is defined as specific areas (listed below) that contain the PBFs considered essential to the conservation of the species. This designation includes the river water, river bottom (including those areas and associated gravel used by SR winter-run Chinook salmon as spawning substrate), and adjacent riparian zone used by fry and juveniles for rearing (58 FR 33212). NMFS limits "adjacent riparian zones" to only those areas above a stream bank that provide cover and shade to the near shore aquatic areas. Although the flood bypasses (e.g., Yolo, Sutter, and Colusa) are not designated critical habitat for SR winter-run Chinook salmon, NMFS recognizes that they may be utilized when inundated with Sacramento River flood flows and are important rearing habitats for juvenile SR winter-run Chinook salmon. Also, juvenile SR winter-run Chinook salmon use many of the tributaries of the Sacramento River for non-natal rearing (Phillis et al. 2018). Critical habitat also includes the estuarine water column and essential foraging habitat and food resources used by SR winter-run Chinook salmon as part of their juvenile out-migration or adult spawning migration.

The following is the status of the PBFs that are considered to be essential for the conservation of SR winter-run Chinook salmon (58 FR 33212):

1. Access from the Pacific Ocean to appropriate spawning areas: Adult migration corridors should provide satisfactory water quality, water quantity, water temperature, water velocity, cover, shelter, and safe passage conditions in order for adults to reach spawning areas. Adult SR winter-run Chinook salmon generally migrate to spawning areas during the winter and spring, at which time, the migration route provides access to the spawning grounds in the upper 60 miles of the Sacramento River. However, much of this habitat is modified or degraded, and SR winter-run Chinook salmon must pass through a fish ladder at the Anderson-Cottonwood Irrigation District (ACID) dam. While a number of chronic stranding locations have been addressed (e.g., Knights Landing Outfall Gates, Wallace Weir and Fremont Weir Adult Fish Passage Modification Project), the potential remains for returning adults to be entrained into the flood bypasses and agricultural drains (Herbold et al. 2018). Since the primary migration corridors are essential for connecting early rearing habitat with the ocean, even the degraded reaches are considered to have a high intrinsic conservation value to the species.

2. The availability of clean gravel for spawning substrate: Suitable spawning habitat for SR winter-run Chinook salmon exists in the upper 60 miles of the Sacramento River between Keswick Dam and Red Bluff Diversion Dam. However, the majority of spawning habitat is only accessible in the first 10 miles below Keswick Dam. This spawning habitat is completely outside the historical range utilized by SR winter-run Chinook salmon, which is upstream of Keswick Dam. Because Shasta and Keswick dams also block gravel recruitment, Reclamation has been adding spawning gravel annually since 2011 downstream of Keswick Dam. Approximately 20,000 tons of gravel was added in September 2019 and gravel has also been added further downstream and under the Market Street Bridge to improve spawning habitat availability. At the Market Street Bridge site, approximately 13,000 tons of gravel was added in 2016, and another 11,900 tons was added in 2019 (Glenn-Colusa Irrigation District (GCID) 2016, Reclamation District 108 (RD108) 2019). Even in degraded reaches, spawning habitat has a high

conservation value, as its function directly affects the spawning success and reproductive potential of listed salmonids.

3. Adequate river flows for successful spawning, incubation of eggs, fry development and emergence, and downstream transport of juveniles: An April 5, 1960, a Memorandum of Agreement between Reclamation and CDFW, formerly the California Department of Fish and Game (CDFG), originally established flow objectives in the Sacramento River for the protection and preservation of fish and wildlife resources. In addition, Reclamation complies with the 1990 flow releases required in State Water Resource Control Board (SWRCB) Water Rights Order (WRO) 90-5 for the protection of Chinook salmon. This order includes a minimum flow release of 3,250 cubic feet per second (cfs) from Keswick Dam downstream to Red Bluff Diversion Dam from September through February during all water year types except critically dry. Although subject to variable hydrology, upper river flows continue to be actively managed by Reclamation in coordination with downstream water users and federal and state resource agencies to minimize redd dewatering and juvenile stranding (U.S. Bureau of Reclamation 2019b). Likewise, recent studies support a refined understanding of the relationship between middle Sacramento River flow and the survival of migrating juvenile Chinook salmon, where survival is maximized at flows between the historic mean flow (10,712 cfs) and high flow (22,872 cfs; Michel 2018, Michel et al. 2021).

4. Water temperatures at 5.8°C to 14.1°C (42.5°F to 57.5°F) for successful spawning, egg incubation, and fry development: Summer flow releases from Shasta Reservoir for agriculture and other consumptive uses drive operations of Shasta and Keswick dam water releases during the period of SR winter-run Chinook salmon holding, spawning, egg incubation, fry development, and emergence. These releases result in an inverse hydrograph compared to pre-dam conditions, where cold water is made available to the accessible spawning habitat downstream of Keswick Dam during the hottest part of the year. The extent to which SR winter-run Chinook salmon habitat needs are met depends on annual hydrology (e.g., reservoir inflow) and Reclamation's other operational commitments, including those to water contractors, Delta requirements pursuant to State Water Rights Decision 1641 (D-1641), and Shasta Reservoir storage constraints. WRO 90-5 requires Reclamation to operate Shasta, and Keswick dams to meet a daily average water temperature of 13.3°C (56°F) at Red Bluff Diversion Dam (river mile 243) or a location upstream when the objective cannot be met at Red Bluff Diversion Dam. Based on these requirements, Reclamation forecasts how far downstream 13.3°C (56°F) can be maintained throughout the SR winter-run Chinook salmon spawning, egg incubation, and fry development stages. However, more recent modeling indicates, for the egg incubation life stage at least, that the thermal tolerance of incubating SR winter-run Chinook salmon eggs may be closer to 12°C (53.6°F), the effects of which are interrelated with dissolved oxygen concentrations (Martin et al. 2017, Martin et al. 2020).

   Every year since WRO 90-5 was issued, operation plans have included modifying the temperature compliance point to make the best use of the cold water available based on water temperature modeling and observed spawning distribution. Once a location has been identified and established, it is generally maintained, and, therefore, water temperatures are typically adequate through the summer for successful SR winter-run

Chinook salmon egg incubation and fry development for those redds constructed upstream of the temperature compliance point (except for in some critically dry or drought years). However, by continually moving the temperature compliance upstream, the value of the available habitat is degraded by reducing the spawning area in size and at times duration, thereby imprinting upon the next generation to return further upstream.

5. Habitat and adequate prey free of contaminants: Although water quality conditions have improved since the 1980s due to stricter standards and Environmental Protection Agency (EPA) Superfund site cleanups (e.g., Iron Mountain Mine), the rate of improvement has slowed over time (San Francisco Estuary Partnership 2019). Likewise, legacy contaminants such as mercury (and methylmercury), polychlorinated biphenyls (PCBs), heavy metals, and persistent organochlorine pesticides continue to be found in watersheds throughout the Central Valley. Although most of these contaminants are at low concentrations, they continue to work their way into the food web, directly and indirectly affecting listed fish populations and their designated critical habitat (Wood et al. 2010, Davis et al. 2018). The potential exposure to contaminated food sources may create delayed sublethal effects that reduce fitness and survival (Laetz et al. 2009, Macneale et al. 2010). Contaminants are most commonly associated with areas of urban development, agriculture, or other anthropogenic activities. In particular, recent research has identified stormwater runoff from roadways causing significant mortalities in salmonids due to effluent toxicity (McIntyre et al. 2018). The array of toxicity is variously attributed to metals from motor vehicle brake pads; vulcanizing agents in tire rubber (Tian et al. 2021); polycyclic aromatic hydrocarbons (PAHs) from vehicle emissions of oil, grease, and exhaust; as well as residential pesticide use. Although the tire particle-associated 6PPD-quinone has only recently been identified, it is widely used by tire manufacturers, and tire dust has been found where urban and rural roadways drain into waterways (Feist et al. 2017, Sutton et al. 2019). Freshwater rearing habitat has a high intrinsic conservation value even if the current conditions are significantly degraded from their natural state.

6. Riparian and floodplain habitat that provides for successful juvenile development and survival: Much of the Sacramento River system is channelized, leveed, and riprapped such that it provides relatively low habitat complexity, a low abundance of food organisms, and offers a reduced protection from predators. Ideal habitat contains natural cover, such as riparian canopy structure, submerged and overhanging large woody material, native aquatic vegetation, large rocks and boulders, side channels, and undercut banks, which can provide juvenile and adult refugia and aid survival and food supply. The lack of riparian vegetation is exacerbated by the inverse hydrology, where high summer flows and relatively low winter flows can prevent seedlings from becoming established. There remain, however, more complex and productive habitats within historical floodplains where setback levees and flood bypasses are seasonally inundated, which provide some habitat heterogeneity. Overall, the current condition of degraded riparian habitat along the main stem Sacramento River restricts juvenile growth and survival (Henderson et al. 2019).

7. Access downstream so that juveniles can migrate from the spawning grounds to San Francisco Bay and the Pacific Ocean: Migratory corridors are found downstream of the

spawning areas below Keswick Dam and include the main stem of the Sacramento River to the Delta, as well as non-natal rearing areas near the confluence of some tributary streams.

Migratory habitat conditions are strongly affected by the presence of barriers, which can include dams (i.e., hydropower, flood control, and irrigation flashboard dams), unscreened or poorly screened diversions, degraded water quality, or behavioral impediments to migration. For successful survival and recruitment of salmonids, freshwater migration corridors must function sufficiently to provide adequate passage. Unscreened diversions that entrain juvenile salmonids are prevalent throughout the main stem Sacramento River and in the Delta (Kimmerer and Nobriga 2008). Predators such as striped bass (*Morone saxatilis*) and Sacramento pikeminnow (*Ptychocheilus grandis*) tend to concentrate immediately downstream of diversions, resulting in increased mortality of juvenile Chinook salmon (Michel et al. 2020).

Water pumping at the CVP and SWP export facilities in the South Delta at times causes the flow in the river to move back upstream (reverse flow), further disrupting the emigration of juvenile SR winter-run Chinook salmon by attracting and diverting them to the interior Delta, where they are exposed to increased rates of predation, other stressors in the Delta, and entrainment at pumping stations (Collaborative Adaptive Management Team and Team 2017). Regardless of the condition, the remaining estuarine areas are of high conservation value because they provide factors which support rearing habitat and act as an area of transition to the ocean environment.

4.2.1. Summary of the Essential Features of Sacramento River Winter-Run Chinook Salmon Critical Habitat

Critical habitat for SR winter-run Chinook salmon is composed of PBFs that are essential for the conservation of SR winter-run Chinook salmon, including upstream and downstream access, and the availability of certain habitat conditions necessary to meet the biological requirements of the species. Currently, many of these PBFs are degraded and provide limited high quality habitat. Additional features that lessen the quality of the migratory corridor for juveniles include unscreened diversions, altered flows to and in the Delta, and the lack of accessible floodplain habitat.

In addition, changing hydrology and water operations during periods of drought that limit the extent of cold water below Shasta Dam have reduced the available spawning habitat. Although the habitat for SR winter-run Chinook salmon has been highly degraded, the importance of the remaining spawning habitat, migratory corridors, and rearing habitat is of high conservation value.

4.3. Central Valley Spring-Run Chinook Salmon

In 1999 (64 FR 50394), NMFS listed CV spring-run Chinook salmon under the ESA and classified it as a threatened species (Table 9). This initial classification was reaffirmed in 2005 when the FRFH population was added to the ESU (70 FR 37160). Critical habitat for CV spring-run Chinook salmon was later designated in 2005 (70 FR 52488).

Table 9. Summary of the listing history under the Endangered Species Act for the Central Valley spring-run Chinook salmon evolutionarily significant unit.

Salmonid Species	ESU/DPS Name	Original Listing	Revised Listing	Critical Habitat Designations
Chinook Salmon (*O. tshawytscha*)	Central Valley spring-run Chinook salmon	**FR Notice:** 64 FR 50394 **Date:** September 16, 1999 **Classification:** Threatened	**FR Notice:** 70 FR 37160 **Date:** June 28, 2005 **Re-affirmation:** Threatened	**FR notice:** 70 FR 52488 **Date:** September 2, 2005

On July 22, 2014 (79 FR 42504), NMFS completed the Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-run Chinook Salmon and Central Valley Spring-run Chinook Salmon and the Distinct Population Segment of California Central Valley Steelhead (National Marine Fisheries Service 2014b). In the following (2016) 5-year review it was recommended that CV spring-run Chinook salmon should remain listed as threatened (81 FR 33468 , National Marine Fisheries Service 2016a).

4.3.1. Life History

Generally, adult CV spring-run Chinook salmon migrate from the Pacific Ocean in a reproductively immature state and swim upstream into fresh water in the spring months (approximately March through June) using olfactory senses to locate their birth waters. The adult fish then hold over summer months (approximately June through September) and spawn in cold freshwater in the early fall months (approximately September through November). Larval fish, also known as alevins, hatch from eggs and emerge from their gravel nests throughout the fall and early winter months (approximately October through December). Juvenile fish then rear and feed in freshwater from late fall through spring (approximately October through June), or they may choose to rear for a full year (i.e., October to subsequent October to December) and become "yearling" juveniles when conditions are suitable.

As juvenile fish rear, they migrate downstream and eventually reach the Delta and then the San Francisco Bay estuary. Once juvenile fish have completed the physiological changes necessary to enter saltwater (called smoltification), they enter the Pacific Ocean and rear until adulthood for approximately 3 to 4 years, which is typical for Chinook salmon. Once adult fish are 3 or 4 years old, they migrate back upstream to freshwater to start the life cycle over again and create the next generation. Table 10 and Table 11 provide temporal occurrences of the various life history stages of CV Chinook salmon in the Sacramento and San Joaquin rivers, respectively.

All Chinook salmon are "semelparous" fish, meaning they reproduce once in their lifetime and then die shortly after spawning. Scientific literature has shown that the decomposing carcasses of ocean-returned salmon provide marine derived nutrients that act like fertilizer to the vegetation

on the river banks or riparian areas (Naiman et al. 2002, Janetski et al. 2009). Carcasses also create important macroinvertebrate communities that are unique to river systems with salmon. Healthy and flourishing riparian vegetation provides food, shade, cover, and water temperature refugia for juvenile salmon and helps improve the survival of the next generation of salmon (National Marine Fisheries Service 2014b).

In general, wetter water years result in higher survival of juveniles out-migrating during the spring of the same year they emerged. In 3 to 4 years, the juvenile cohort that experienced wetter out-migration conditions are more likely to result in a higher abundance of adults returning to freshwater to spawn. Drier water years generally result in low survival during spring out-migration and encourage a subset (roughly 10 percent) of juveniles to express the yearling life history strategy (Cordoleani et al. 2021). This results in a lower number of large juveniles out-migrating to the ocean much later in the year. When the dry condition cohort returns as adults, there are fewer adults because there was less survival during the large spring out-migration. Therefore, the number of adult spawners is likely to be lower from a juvenile cohort that experienced drought conditions in freshwater during their out-migration in contrast to a juvenile cohort that experiences high river flows during a wet water year while out-migrating.

Table 10. The temporal occurrence of (a) adult, (b) adult holding, (c) adult spawning, and (d) juvenile Central Valley spring-run Chinook salmon in the Sacramento River.

(a) Adult Migration

Time Period and Location	Early Jan	Late Jan	Early Feb	Late Feb	Early Mar	Late Mar	Early Apr	Late Apr	Early May	Late May	Early Jun	Late Jun	Early Jul	Late Jul	Early Aug	Late Aug	Early Sep	Late Sep	Early Oct	Late Oct	Early Nov	Late Nov	Early Dec	Late Dec
Sacramento river basin	N	N	N	N	M	M	M	M	H	H	H	H	M	M	M	M	M	M	L	N	N	N	N	N
Sacramento River mainstem	N	L	L	L	M	M	M	M	M	M	M	M	M	M	L	L	N	N	N	N	N	N	N	N
Mill Creek	N	N	N	N	L	L	M	H	H	H	H	M	M	L	L	N	N	N	N	N	N	N	N	N
Deer Creek	N	N	N	N	L	L	M	H	H	H	H	M	M	N	N	N	N	N	N	N	N	N	N	N
Butte Creek	N	N	L	M	M	M	M	H	H	H	H	M	L	N	N	N	N	N	N	N	N	N	N	N
(b) Adult Holding	N	N	N	L	L	M	M	H	H	H	H	H	H	H	H	M	M	L	L	N	N	N	N	N
(c) Adult Spawning	N	N	N	N	N	N	N	N	N	N	N	N	N	N	L	M	H	H	M	L	N	N	N	N

(d) Juvenile Migration

Time Period and Location	Early Jan	Late Jan	Early Feb	Late Feb	Early Mar	Late Mar	Early Apr	Late Apr	Early May	Late May	Early Jun	Late Jun	Early Jul	Late Jul	Early Aug	Late Aug	Early Sep	Late Sep	Early Oct	Late Oct	Early Nov	Late Nov	Early Dec	Late Dec
Sacramento River tributaries	M	M	M	M	M	M	N	N	N	N	N	N	N	N	N	N	N	N	M	M	H	H	H	H
Upper Butte Creek	H	H	H	H	M	M	M	M	M	M	L	L	N	N	N	N	N	N	L	L	L	L	H	H
Mill, Deer, Butte creeks	H	H	H	H	M	M	M	M	M	M	L	L	N	N	N	N	N	N	L	L	L	L	L	L
Sacramento River at Red Bluff Diversion Dam	H	H	L	L	L	L	L	L	L	N	N	N	N	N	N	N	N	N	N	N	H	H	H	H
Sacramento River at Knights Landing	M	M	M	M	H	H	H	H	M	M	N	N	N	N	N	N	N	N	N	N	M	M	H	H

Sources: (California Department of Fish and Game 1998, Myers et al. 1998, Yoshiyama et al. 1998, Snider and Titus 2000, Moyle 2002, Ward et al. 2003, Lindley et al. 2004, McReynolds et al. 2007, CalFish 2019)

Note: Yearling Central Valley spring-run Chinook salmon rear in their natal streams through the first summer following their birth. Downstream emigration generally occurs the following fall and winter. Most young-of-the-year Central Valley spring-run Chinook salmon emigrate during the first spring after they hatch.

Darker shades indicate months of greatest relative abundance.

Relative Abundance: H = High M = Medium L = Low N = Not Present

Table 11. The temporal occurrence of (a) adult, (b) adult holding, (c) adult spawning, and (d) juvenile Central Valley spring-run Chinook salmon in the San Joaquin River.

(a) Adult Migration

Time Period and Location	Early Jan	Late Jan	Early Feb	Late Feb	Early Mar	Late Mar	Early Apr	Late Apr	Early May	Late May	Early Jun	Late Jun	Early Jul	Late Jul	Early Aug	Late Aug	Early Sep	Late Sep	Early Oct	Late Oct	Early Nov	Late Nov	Early Dec	Late Dec
San Joaquin river basin	N	N	N	N	M	M	M	M	H	H	H	H	M	M	M	M	M	M	L	N	N	N	N	N
San Joaquin River mainstem	N	L	L	L	M	M	M	M	M	M	M	M	M	M	M	L	L	N	N	N	N	N	N	N
Stanislaus River	N	N	N	N	L	L	M	H	H	H	H	M	M	L	L	N	N	N	N	N	N	N	N	N
Tuolumne River	N	N	N	N	L	L	M	H	H	H	H	M	M	N	N	N	N	N	N	N	N	N	N	N
Merced River	N	N	L	M	M	M	M	H	H	H	H	M	L	N	N	N	N	N	N	N	N	N	N	N
(b) Adult Holding	N	N	N	L	L	M	M	H	H	H	H	H	H	H	H	M	M	L	L	N	N	N	N	N

Time Period and Location	Early Jan	Late Jan	Early Feb	Late Feb	Early Mar	Late Mar	Early Apr	Late Apr	Early May	Late May	Early Jun	Late Jun	Early Jul	Late Jul	Early Aug	Late Aug	Early Sep	Late Sep	Early Oct	Late Oct	Early Nov	Late Nov	Early Dec	Late Dec
(c) Adult Spawning	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	L	M	H	H	H	M	L	N	N	N

(d) Juvenile Migration

Time Period and Location	Early Jan	Late Jan	Early Feb	Late Feb	Early Mar	Late Mar	Early Apr	Late Apr	Early May	Late May	Early Jun	Late Jun	Early Jul	Late Jul	Early Aug	Late Aug	Early Sep	Late Sep	Early Oct	Late Oct	Early Nov	Late Nov	Early Dec	Late Dec
San Joaquin River mainstem	H	H	H	H	H	H	H	H	M	M	L	L	N	N	N	N	N	N	L	L	M	M	H	H
Stanislaus River	H	H	H	H	M	M	M	M	M	M	L	L	N	N	N	N	N	N	L	L	M	M	H	H
Tuolumne River	H	H	H	H	M	M	M	M	M	M	L	L	N	N	N	N	N	N	L	L	M	M	H	H
Merced River	H	H	H	H	M	M	M	M	M	M	L	L	N	N	N	N	N	N	L	L	M	M	H	H

Sources: (California Department of Fish and Game 1998, Myers et al. 1998, Yoshiyama et al. 1998, Moyle 2002, Ward et al. 2003, Lindley et al. 2004, McReynolds et al. 2007, He and Stuart 2016, U.S. Fish and Wildlife Service 2019)

Note: Yearling Central Valley spring-run Chinook salmon rear in their natal streams through the first summer following their birth. Downstream emigration generally occurs the following fall and winter. Most young-of-the-year Central Valley spring-run Chinook salmon emigrate during the first spring after they hatch.

Darker shades indicate months of greatest relative abundance.

Relative Abundance: H = High M = Medium L = Low N = Not Present

4.3.2. Population Structure

The CV spring-run Chinook salmon ESU includes all naturally spawned CV spring-run Chinook salmon originating from the Sacramento River and its tributaries (70 FR 37160). The ESU also includes CV spring-run Chinook salmon from the FRFH spring-run Chinook salmon program. In 2014, FRFH broodstock was used to actively reintroduce CV spring-run Chinook salmon into the mainstem San Joaquin River as an ESA 10(j) experimental population (78 FR 79622). Since 2019, adults have been observed returning to the San Joaquin River and successfully spawning within the SJRRP Restoration Area.

There have also been observations of CV spring-run Chinook salmon returning to the San Joaquin River tributaries and creating redds. Genetic assessment of both unmarked (no presence of a CWT or clipped adipose fin, either of which indicates hatchery origin) adult carcasses and out-migrating juveniles is underway and will inform the origin of these fish. The presence of

spent (indication of spawning) carcasses of adult CV spring-run Chinook salmon from the SJRRP have been confirmed on the Stanislaus, Tuolumne, and Merced rivers using CWTs.[5]

The listed ESU does not include CV spring-run Chinook salmon that are designated as part of the SJRRP NEP population[6]. Continuing to monitor these populations will provide valuable data to evaluate the status of CV spring-run Chinook salmon in the San Joaquin River and its tributaries. This monitoring would also provide a basis for evaluating whether the ESU boundary should be modified to account for CV spring-run Chinook salmon populations repopulating the San Joaquin river basin and/or in CV habitats upstream of currently impassable barriers (Gutierrez et al. 2024).

The NMFS-appointed Central Valley Technical Recovery Team delineated independent CV Chinook salmon populations and grouped them into four diversity groups based on climatological, hydrological, and geological characteristics. The CV spring-run Chinook salmon ESU is composed of four diversity groups: Basalt and Porous Lava, Northwestern California, Northern Sierra Nevada, and Southern Sierra Nevada.

Recovery strategies outlined in the NMFS' CV Recovery Plan (National Marine Fisheries Service 2014b) are targeted on achieving, at a minimum, the biological viability criteria for each major diversity group in the ESU in order to have all four diversity strata at viable (low risk) status with representation of all the major life history strategies present historically and with the abundance, productivity, spatial structure, and diversity attributes required for long-term persistence.

In order to meet the recovery criteria for this ESU and thereby delist the species, there must be at least nine populations at a low risk of extinction distributed throughout the Central Valley, as well as additional populations at a moderate risk of extinction.

- One population in the Northwestern California Diversity Group at low risk of extinction
- Two populations in the Basalt and Porous Lava Diversity Group at low risk of extinction
- Four populations in the Northern Sierra Nevada Diversity Group at low risk of extinction
- Two populations in the Southern Sierra Nevada Diversity Group at low risk of extinction
- Maintain multiple populations at moderate risk of extinction

4.3.3. Viability Status and Trends

Abundance and Productivity

[5] CWTs can be found online at https://www.rmpc.org/.

[6] CV spring-run Chinook salmon only when, and at such times as, they are found in the San Joaquin River from Friant Dam downstream to its confluence with the Merced River, delineated by a line between decimal latitude and longitude coordinates: 37.348930°N., 120.975174°W. and 37.349099°N., 120.974749°W., as well as all sloughs, channels, floodways, and waterways connected with the San Joaquin River within those coordinates that allow for CV spring-run Chinook salmon access, but excluding the Merced River. Also, Central Valley spring-run Chinook salmon when found in portions of the Kings River that connect with the San Joaquin River during high water years (78 FR 79622, December 31, 2013)

The viability of CV spring-run Chinook salmon has deteriorated since the 2015 assessment with weakening of all independent CV spring-run Chinook salmon populations (Table 12). In fact, Mill, Deer, Battle, and Butte creeks changed from a low/moderate to a high risk of extinction using one or more viability criteria (Table 12).

The total estimated abundance of adult CV spring-run Chinook salmon for the Sacramento River watershed in 2019 was 26,553, approximately half of the population size in 2014 (N = 56,023). Also, population sizes have hit decadal lows, of approximately 14,000 individuals, as recently as the last 2 years (Azat 2020). The Central Valley-wide abundance is driven largely by the annual variation in adults returning to Butte Creek.

The Butte Creek population is at a high risk of extinction based on viability analysis using data through 2021. Pre-spawn mortality in 2021 was 92 percent, representing a biologically significant loss in spawning potential. However, given the robust spawning populations in 2019, the total population size (17,951) and average population size remain well above the criteria for low risk of extinction (greater than 2,500). Still, the rate of decline increased from 5 percent per year through 2019, to 19 percent over the most recent 10 years, indicating that the Butte Creek population is at a high risk of extinction (Johnson et al. 2023b).

The Butte Creek CV spring-run Chinook salmon population is wholly dependent on the reliable, long-term import of cold water from the West Branch of the Feather River to spawning and holding habitat in Butte Creek. In February 2017, the Pacific Gas & Electric Company (PG&E) submitted notice to FERC that it was withdrawing its October 2007 application for a new license for the Project (FERC Project No. 803) that moves this water, citing declining power values and the anticipated cost of project operation associated with new license conditions. The Butte Creek CV spring-run population has been a stronghold for the CV spring-run Chinook salmon ESU due to its relatively large population size that has resulted from improvements in water temperature management, extensive fish passage restoration, and the accessibility of floodplain habitat in the Butte Sink and Sutter Bypass for juvenile rearing in the majority of years.

Most dependent CV spring-run Chinook salmon populations have been experiencing continued, and in some cases drastic, declines. For example, while adults were observed in Big Chico Creek from 2014 to 2018, they likely did not survive to spawn due to high summer temperatures resulting in zeros (0) in the escapement estimates (Azat 2020, Johnson et al. 2023b). These results underscore the need for improved passage so that these dependent populations and habitats do not become sinks for CV spring-run Chinook salmon.

Counteracting recent declines in the abundance of adults from dependent populations, CV spring-run Chinook salmon have continued to repopulate areas where they were once extirpated, including Battle and Clear creeks and, more recently, the San Joaquin River. Each of these watersheds have the potential to support independent and viable CV spring-run Chinook salmon populations (Lindley et al. 2004, National Marine Fisheries Service 2014b).

Table 12. Summary of Central Valley spring-run Chinook salmon extinction risk by population criteria described in Lindley et al. (2007) for the 2010, 2015, and 2020 viability assessment periods (Johnson et al.

2022) undated with the results from the mid-cycle assessment. Overall risk is determined by the highest risk score for any criterion.

Population	Extinction Risk for Viability Assessment Year 2010	Extinction Risk for Viability Assessment Year 2015	Extinction Risk for Viability Assessment Year 2020	Extinction Risk for Viability Assessment Year 2022 (mid-cycle)
Mill Creek*	High	Moderate	High	High
Deer Creek*	High	Moderate	High	High
Butte Creek*	Low	Moderate	Moderate	High**
Battle Creek*	High	Moderate	High	High
Clear Creek	High	Moderate	High	Moderate
Feather River Hatchery	High	High	High	High

*Mill, Deer, Butte, and Battle creeks are independent populations.

**The point estimate for the decline in population abundance over the most recent 10 years is 19 percent per year, placing the population at a high risk of extinction (Lindley et al. 2007). The viability criteria for population decline (<10 percent per year) is based on the point estimate with no guidance on interpreting confidence intervals. The confidence intervals for Butte Creek overlap '0' which means that the slope is not statistically different from '0.' We apply the Lindley et al. (2007) decline criteria as it stands, but note that new criteria perhaps in a Baysean framework would provide a clearer ability to assess the probability of extinction given observed declines.

CV spring-run Chinook salmon populations have experienced a series of droughts over the past decade. From 2007 to 2009, 2012 to 2015, and 2020 to 2022, the Central Valley experienced drought conditions and low river and stream discharges, which are strongly associated with lower survival of Chinook salmon. The impacts of the recent drought series and warm ocean conditions on the juvenile life stage seems to have manifested in the low run sizes in 2015–2018 for most CV spring-run Chinook salmon populations (Southwest Fisheries Science Center 2022).

The 2007–2009 and 2012–2015 droughts impacted CV spring-run Chinook salmon adults on Butte Creek, which experienced lethal temperatures in holding habitats during the summer. Pre-spawn mortality was observed during drought years, affecting 1,054, 903, and 232 individuals in 2008, 2013, and 2014, respectively (Garman 2016). In 2015, late-arriving adults observed in sections of Butte Creek near the city of Chico experienced exceptionally warm June air temperatures coupled with the PG&E flume shutdown, resulting in a fish mortality event. These conditions likely influenced juvenile production that resulted in low adult returns in 2015–2018. Fortunately, the favorable hydroclimatic conditions in 2017 appear to have bolstered juvenile survival leading to high adult returns on Butte Creek to approximately 15,000 adults.

At the ESU level, the spatial diversity of CV spring-run Chinook salmon is increasing and CV spring-run Chinook salmon are present (albeit at low numbers in some cases) in all diversity groups. The reestablishment of CV spring-run Chinook salmon to Battle and Clear creeks starting in the late 1990s and early 2000s, along with the increasing abundance of CV spring-run Chinook salmon on Clear Creek observed in some years, is benefiting the viability of CV spring-run Chinook salmon. Similarly, CV spring-run Chinook salmon have been documented on the San Joaquin River tributaries and may be the beginning of natural dispersal processes into rivers where they were once extirpated.[7]

Spatial Structure and Diversity

The spatial diversity of CV spring-run Chinook salmon ESU is trending in a positive direction towards achieving at least two populations in each of the four historical diversity groups, but the new populations are not well monitored and likely dependent on emigration for their persistence (National Marine Fisheries Service 2014b). Active reintroduction efforts, like that below Friant Dam on the mainstem San Joaquin River, are necessary to move CV spring-run Chinook salmon towards recovery and additional reintroduction opportunities are being explored on the Yuba River above Englebright Dam, on the Sacramento River above Shasta Dam, on the Tuolumne River above Don Pedro Dam, and on the Feather River above Oroville Dam.

The most acute causes for concern for the long-term viability of the CV spring-run Chinook salmon ESU are:

- biologically significant and catastrophic decline of the Butte Creek population within the last 10 years (Johnson et al. 2023b)
- high pre-spawn mortality and poor juvenile survival during the 2012–2015 and 2020–2022 droughts
- unknown impacts due to warm ocean conditions and reorganization of coastal marine food webs contributing to the emergence of thiamine deficiency as a source of mortality
- the uncertain future of hydroelectric facilities that import cold water to Butte Creek

In addition, the number of Mill and Deer Creek spawners in 2020 was low (Southwest Fisheries Science Center 2022, Johnson et al. 2023b) and preliminary genetic results from the 2021 carcass surveys in these streams lacked the genetic signals specific to the Mill and Deer Creek populations (Johnson et al. 2023b). It is therefore possible that consecutive years of very low returns has resulted in extirpation of this unique genetic lineage. More research and analysis are currently being conducted to determine the extent of the damage to this population (Johnson et al. 2023b).

[7]CWTs can be found online at https://www.rmpc.org/.

4.3.4. Recovery

4.3.4.1. Limiting factors and threats

Below are explanations of three of the most limiting factors and threats to CV spring-run Chinook salmon recovery. These three are by no means the only factors limiting recovery but they are major factors limiting recovery.

Habitat

Access to historical CV spring-run Chinook salmon habitat is severely limited by high head dams along the Sierra Nevada Mountains and Coastal Range. The current populations are sequestered on the Central Valley floor outside of their historical high elevation cold water habitats. This creates difficult conditions for adults holding over the hot summer months. Furthermore, both the Sacramento and San Joaquin rivers are highly channelized and locked into their current formations by extensive levee systems. This effectively blocks the river access to wetland and floodplain habitats, which are important to juvenile growth and rearing during their out-migration. While some conservation measures have been successful in improving habitat conditions for the CV spring-run Chinook salmon ESU since it was listed in 1999, fundamental problems with the quality of remaining habitat persist (Cummins et al. 2008, Lindley et al. 2009, National Marine Fisheries Service 2014b, Southwest Fisheries Science Center 2022). As such, the habitat supporting this ESU remains in a highly degraded state and the habitat quality has not substantially improved since the last 5-year review in 2016 (National Marine Fisheries Service 2016a).

Drought

Historical precipitation and streamflow in the Sacramento River watershed are highly variable, with recent years 2017, 2019, and 2023 being above-average water years and 2016, 2018, and 2020–2022 being below-average water years. Overall, rising atmospheric temperatures have exacerbated an already high evaporative demand in the region such that the region frequently experiences a significant moisture deficit. The moisture deficit results in low-flow and warm water temperatures in the Sacramento River that in turn limits successful spawning, egg incubation, fry development, and emergence. Droughts also affect the broader landscape where forests are already showing evidence of increased aridification in the form of forest fire severity and insect outbreak (Halofsky et al. 2020), which can have cascading effects on the aquatic environment.

Hatchery Impacts

Hatchery programs can affect naturally produced populations of salmon and steelhead in a variety of ways, including competition (for spawning sites and food) effects, predation effects, disease effects, genetic effects (e.g., outbreeding depression and hatchery-influenced selection), broodstock collection effects (e.g., to population diversity), and facility effects (e.g., water withdrawals and effluent discharge.

4.3.4.2. Recovery Goals/Priorities

NMFS completed a recovery plan for CV spring-run Chinook salmon in 2014 (National Marine Fisheries Service 2014b). The recovery plan rationale is based on two key principles: it is necessary to have functioning, diverse, and interconnected habitats for population viability, and viability is based on spatial structure, diversity, productivity, and abundance (McElhany et al. 2000). The greatest opportunities for advancing CV spring-run Chinook salmon recovery are to preserve current populations and reintroduce populations into their historical habitat. To support preservation and reintroduction, the limiting factors discussed above and in the status review need to be addressed.

Specific recovery goals are: (1) securing adequate flows and temperatures for holding adults and yearling juveniles; (2) improving rearing habitat and increasing survival for out-migrating juveniles; (3) completing major fish passage projects on CV spring-run Chinook salmon habitat on the Sacramento and San Joaquin rivers and their tributaries; and (4) operating water movement and diversion facilities while maintaining and enhancing the function of migration corridors and freshwater and estuarine rearing habitats. Moving towards these goals will create a functioning ecosystem.

4.3.4.3. Recovery Plan Core Classifications and Primary Reintroduction Watersheds

The NMFS Recovery Plan for Central Valley Salmon and Steelhead (National Marine Fisheries Service 2014b) developed watershed classifications to assess the potential for populations to contribute to species recovery. There are three categories: Core 1, Core 2, and Core 3. The NMFS Recovery Plan for Central Valley Salmon and Steelhead also identifies primary, candidate, and non-candidate watersheds for reintroduction to historic habitats. Primarily reintroduction watersheds have the highest reintroduction priority.

- Core 1 populations meet or have the potential to meet the long-term objective of low extinction risk. These populations possess the known ability or potential ability to support a viable population.
- Core 2 populations meet or have the potential to meet the biological recovery criteria for a moderate risk of extinction. These populations have lower potential to support viable populations due to lower abundance or amount and quality of habitat. They can contribute to increased diversity for a species and may provide resilience from catastrophic events that impact other populations.
- Core 3 populations are present in watersheds on an intermittent basis and require straying from other populations for their existence. They can contribute to increased diversity for a species and may provide resilience from catastrophic events that impact other populations.

Central Valley spring-run Chinook salmon occur across four diversity groups in the Central Valley: the Basalt and Porous Lava Diversity Group, the Northwestern California Diversity Group, the Northern Sierra Diversity Group, and the Southern Sierra Diversity Group.

Basalt and Porous Lava Diversity Group - The following Core classifications and primary reintroduction are identified in the NMFS Recovery Plan for Salmon and Steelhead:

- Core 1: Battle Creek
- Core 2: Mainstem Sacramento River
- Core 3: There are no Core 3 populations in this diversity group
- Primary reintroduction watershed: McCloud River

Northwestern California Diversity Group - The following Core classifications and primary reintroduction watersheds are identified in the NMFS Recovery Plan for Salmon and Steelhead:

- Core 1: Clear Creek
- Core 2: Cottonwood/Beegum Creek
- Core 3: Thomes Creek and Stony Creek
- There are no primary reintroduction watersheds in this diversity group

Northern Sierra Nevada Diversity Group - The following Core classifications and primary watersheds for reintroduction are identified in the NMFS Recovery Plan for Salmon and Steelhead:

- Core 1: Deer, Mill, and Butte creeks
- Core 2: Antelope Creek and Feather and Yuba rivers
- Core 3: There are no Core 3 populations in this diversity group
- Primary reintroduction watershed: Yuba River

Southern Sierra Nevada Diversity Group - The following Core classifications and primary reintroduction watersheds are identified in the NMFS Recovery Plan for Salmon and Steelhead:

- Core 1: There are no Core 1 populations in this diversity group
- Core 2: There are no Core 2 populations in this diversity group
- Core 3: There are no Core 3 populations in this diversity group
- Primary reintroduction watershed: San Joaquin River downstream from Friant Dam. The Stanislaus River upstream from New Melones is a Candidate area for reintroduction.

4.3.4.4. Climate Change

Several factors contributed to the ranking of this ESU as very highly vulnerable to climate change. The poor population viability of this single population spawning outside of its historical range was the greatest risk, as the ESU is not thriving under current climate conditions which are expected to worsen. Both adult and juvenile life stages are vulnerable to hydrologic regime changes, increases in stream temperature, and summer water deficits and are therefore also vulnerable to cumulative life cycle impacts over multiple life stages. Juveniles are also vulnerable to changes in spring flooding and snow melt, as decreased streamflows and incidents of flooding may limit their ability to use productive floodplain habitat for rearing. Sea level rise may also reduce the availability of tidal marsh habitats for rearing juveniles.

CV spring-run Chinook salmon were ranked highly sensitive (Figure 11) because they are in the southernmost region of the range of Chinook salmon on the West Coast, and the California Central Valley offers the fewest opportunities for adaptive capacity of the Chinook salmon recovery domains. The limited phenotypic and genetic diversity remaining in the extant

population combined with the currently inaccessible historic habitat is also likely to limit this ESU's ability to adapt to future climate change.

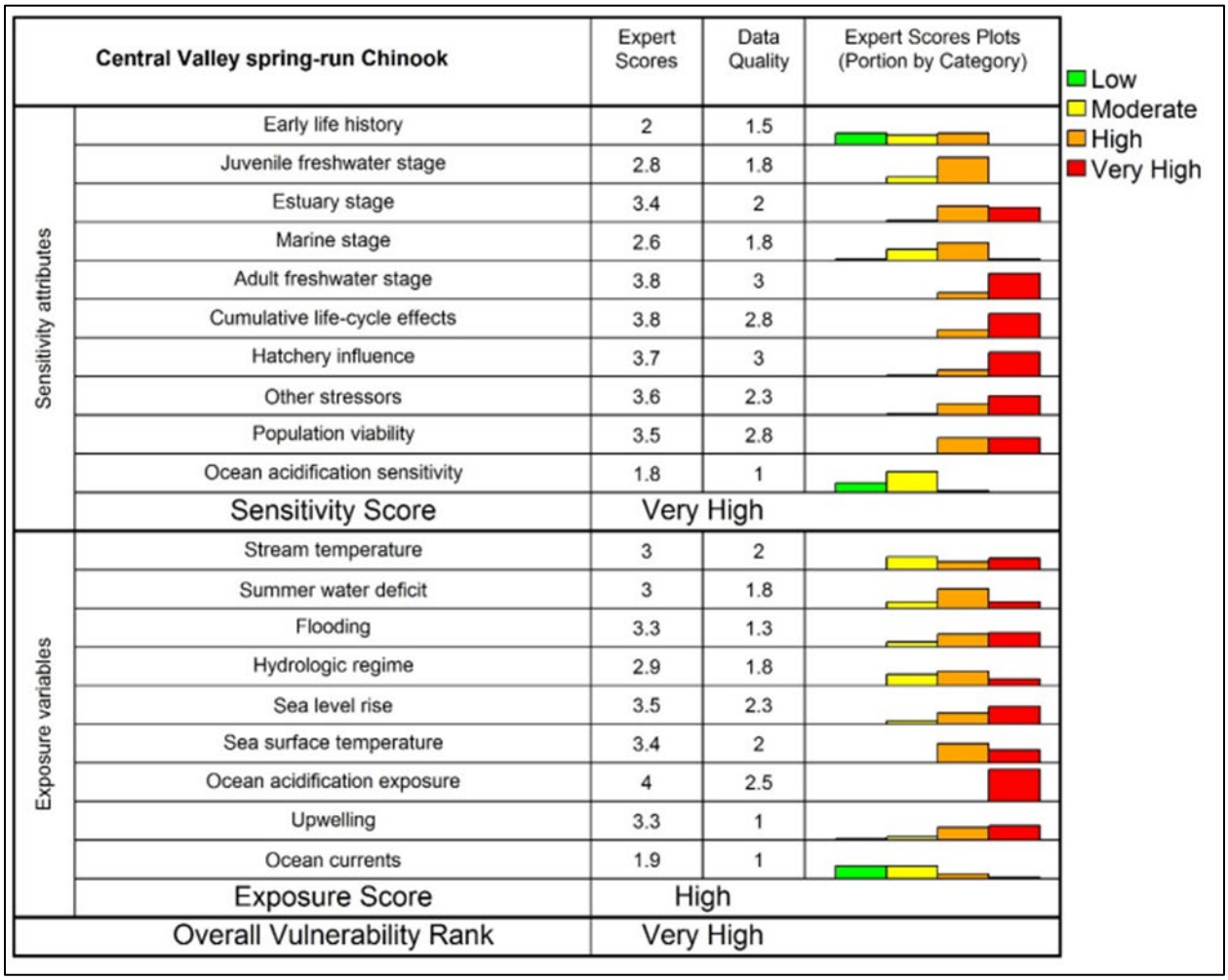


Figure 11. Central Valley spring-run Chinook salmon Climate Effects Exposure and Vulnerability.

Source: (Crozier et al. 2019)

CV spring-run Chinook salmon evolved multiple life history strategies in response to the hydrologic variability of California's Central Valley. The preservation of these life history strategies is dependent on the preservation of the natural hydrograph and functional freshwater habitats that support survival throughout the juvenile migration timeframe (both early [young-of-year] and late migrating [yearlings]). In some years, the early out-migration life history strategy may be more advantageous for juvenile survival due to certain environmental conditions (i.e., wetter hydrologic conditions). In other years, the late out-migration life history strategy may be more advantageous for juvenile survival, such as in drier hydrologic conditions (Cordoleani et al. 2021). This variation in juvenile life history strategies creates multiple generations of adults

returning to spawn in freshwater. Multiple age classes of spawning adults are necessary to ensure the overall survival of Chinook salmon against drastic annual hydrologic variations.

However, the effects of climate change impact the entire salmonid watershed, from freshwater to saltwater, and thus will likely make survival more difficult during both the juvenile and adult migration timeframes. As discussed above, climate change will alter hydrologic conditions throughout the Central Valley and has the potential to significantly reduce or eliminate life history strategies across multiple generations of Chinook salmon. The combined factors of climate change, highly managed and unnatural hydrographs, disconnected floodplains, and the lack of passage to historical upper watershed habitats pose a significant and severe threat to the survival of CV spring-run Chinook salmon.

Climate change will continue to be a threat towards the recovery of CV spring-run Chinook salmon (National Marine Fisheries Service 2014b, Southwest Fisheries Science Center 2022, Johnson et al. 2023b). In particular, more frequent and longer duration droughts in the southern Sierra-Nevada Mountain Range will have a significant impact on water supply and reliability for both people and fish. Increased drought frequency, combined with an overall decrease in snow pack, will decrease the quantity of cold water. Lack of access to high elevation spawning and rearing habitats due to impassable dams will result in decreased survival and abundance for both the juvenile and adult life stages of salmon in the San Joaquin River.

4.3.5. Summary

To conclude, the viability of the CV spring-run Chinook salmon ESU has deteriorated since it was added to the ESA (National Marine Fisheries Service 2016a, Johnson et al. 2023b). The largest impacts are likely due to the 2012–2015 and 2020–2022 freshwater drought conditions and unusually warm ocean conditions experienced by these cohorts, resulting in weakening viability metrics and greater risks of extinction to the majority of the CV spring-run Chinook salmon along with lack of access to historic and floodplain habitat.

Overall, the SWFSC's viability assessment (Johnson et al. 2023b) concluded that the viability of CV spring-run Chinook salmon (through 2021) has declined since the prior viability assessment in 2016 and that the ESU's extinction risk may have increased. This ESU continues to face significant, unyielding threats that are likely to be exacerbated by the impacts of future climate change. Significant habitat and flow improvement actions are urgently needed to recover the species.

4.4. Designated Critical Habitat for Central Valley Spring-Run Chinook Salmon

Critical habitat was designated for CV spring-run Chinook salmon on September 2, 2005 (70 FR 52488). Critical habitat for the CV spring-run Chinook salmon includes stream reaches of the Feather, Yuba, and American rivers; Big Chico, Butte, Deer, Mill, Battle, Antelope, and Clear creeks; and the Sacramento River, as well as portions of the northern Delta. Critical habitat includes the stream channels in the designated stream reaches (70 FR 52488). Critical habitat for CV spring-run Chinook salmon is defined as specific areas that contain the PCEs and physical habitat elements essential to the conservation of the species. The following are the PCEs for CV spring-run Chinook salmon.

4.4.1. Spawning Habitat

Freshwater spawning sites are those with sufficient water quantity and quality conditions and substrate supporting spawning, incubation, and larval development. Most spawning habitat in the Central Valley for Chinook salmon is located in areas directly downstream of dams containing suitable environmental conditions for spawning and incubation. Spawning habitat for CV spring-run Chinook salmon occurs on the mainstem Sacramento River between the Red Bluff Diversion Dam and Keswick Dam and in tributaries such as Mill, Deer, and Butte creeks, as well as the Feather and Yuba rivers and Big Chico, Battle, Antelope, and Clear creeks. Even in degraded reaches, spawning habitat has a high conservation value as its function directly affects the spawning success and reproductive potential of listed salmonids.

4.4.2. Freshwater Rearing Habitat

Freshwater rearing sites are those with water quantity and floodplain connectivity to form and maintain physical habitat conditions that support juvenile growth and mobility; water quality and forage supporting juvenile salmonid development; and natural cover such as shade, submerged and overhanging large woody material, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks. Both spawning areas and migratory corridors comprise rearing habitat for juveniles, which feed and grow before and during their out-migration. Non-natal, intermittent tributaries also may be used for juvenile rearing. Rearing habitat condition is strongly affected by habitat complexity, food supply, and the presence of predators of juvenile salmonids. Some complex, productive habitats with floodplains remain in the system (e.g., the lower Cosumnes River, Sacramento River reaches with setback levees [i.e., primarily located upstream of the City of Colusa]) and flood bypasses (i.e., Yolo and Sutter bypasses). However, the channelized, leveed, and riprapped river reaches and sloughs that are common in the Sacramento-San Joaquin system typically have low habitat complexity, low abundance of food organisms, and offer little protection from piscivorous fish and birds. Freshwater rearing habitat also has a high intrinsic conservation value even if the current conditions are significantly degraded from their natural state.

4.4.3. Freshwater Migration Corridors

Ideal freshwater migration corridors are free of migratory obstructions, with water quantity and quality conditions that enhance migratory movements. They contain natural cover such as riparian canopy structure, submerged and overhanging large woody objects, aquatic vegetation, large rocks and boulders, side channels, and undercut banks which augment juvenile and adult mobility, survival, and food supply. Migratory corridors are downstream of the spawning areas and include the lower main stems of the Sacramento and San Joaquin rivers and the Delta. These corridors allow the upstream passage of adults and the downstream emigration of juveniles. Migratory habitat conditions are strongly affected by the presence of barriers, which can include dams (i.e., hydropower, flood control, and irrigation flashboard dams), unscreened or poorly screened diversions, degraded water quality, or behavioral impediments to migration. For successful survival and recruitment of salmonids, freshwater migration corridors must function sufficiently to provide adequate passage. The stranding of adults has been known to occur in flood bypasses and associated weir structures (Vincik and Johnson 2013) and a number of challenges exist on many tributary streams. For juveniles, unscreened or inadequately screened

water diversions throughout their migration corridors and a scarcity of complex in-river cover have degraded this PCE. However, since the primary migration corridors are used by numerous populations and are essential for connecting early rearing habitat with the ocean, even the degraded reaches are considered to have a high intrinsic conservation value to the species.

4.4.4. Estuarine Areas

Estuarine areas, such as the San Francisco Bay and the downstream portions of the Delta, free of migratory obstructions with water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between freshwater and saltwater are included as a PCE. Natural cover such as submerged and overhanging large woody material, aquatic vegetation, and side channels are suitable for juvenile and adult foraging.

The remaining estuarine habitat for these species is severely degraded by altered hydrologic regimes, poor water quality, reductions in habitat complexity, and competition for food and space with exotic species. Regardless of the condition, the remaining estuarine areas are of high conservation value because they provide factors which function to provide predator avoidance, rearing habitat, and as an area of transition to the ocean environment.

4.5. California Central Valley Steelhead

4.5.1. Introduction and Background

The CCV steelhead DPS includes naturally spawned anadromous *O. mykiss* originating below natural and manmade impassable barriers from the Sacramento and San Joaquin rivers and their tributaries and excludes such fish originating from the San Francisco and San Pablo Bays and their tributaries (70 FR 37160). This DPS includes CCV steelhead from the Coleman National Fish Hatchery, FRFH, and the Mokelumne River Hatchery (85 FR 81822).

4.5.1.1. Listing Classification and Date

In 1998, NMFS listed CCV steelhead under the ESA and classified it as a threatened species (Table 13). In 2006, following the development of NMFS' Hatchery Listing Policy (70 FR 37204), we re-evaluated the status of this DPS and determined that the DPS continued to warrant listing as a threatened species. Furthermore, we determined that the Coleman National Fish Hatchery and FRFH stocks of CCV steelhead should be part of the DPS (Table 13). In 2020, NMFS added the Mokelumne River Hatchery to the CCV steelhead DPS because fish in this program are genetically most similar to FRFH Program steelhead, which are included in the DPS (85 FR 81822).

Table 13. Summary of the listing history under the Endangered Species Act for the California Central Valley steelhead distinct population segment.

Salmonid Species	ESU/DPS Name	Original Listing	Revised Listing(s)
Steelhead (*O. mykiss*)	California Central Valley Steelhead	**FR Notice:** 63 FR 13347 **Date:** March 19, 1998 **Classification:** Threatened	**FR Notice:** 71 FR 834 **Date:** January 5, 2006 **Re-affirmation:** Threatened

4.5.1.2. Recovery Plan and Five-Year Review

On July 22, 2014 (79 FR 42504), NMFS completed the Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-run Chinook Salmon and Central Valley Spring-run Chinook Salmon and the Distinct Population Segment of California Central Valley Steelhead (National Marine Fisheries Service 2014b). In the following (2016) 5-year review it was recommended that the CCV steelhead DPS should remain listed as threatened (81 FR 33468 , National Marine Fisheries Service 2016b).

4.5.2. Life History and Distribution

O. mykiss exhibit a diverse life history (Moyle 2002). Members of this species can be anadromous or freshwater residents, and, under some circumstances, members of one form can yield offspring of another form (Zimmerman et al. 2008).

California Central Valley steelhead adult migration from the ocean to spawning grounds occurs during much of the year, with peak migration occurring in the fall or early winter (Moyle 2002). California Central Valley steelhead generally begin spawning in December, continuing through March/April (Moyle 2002).

California Central Valley steelhead spawn downstream of dams on every major tributary within the Sacramento and San Joaquin River systems. Due to water development projects, most spawning is now confined to lower stream reaches below dams. In a few streams, such as Mill and Deer creeks, CCV steelhead still have access to historical spawning areas (McEwan and Jackson 1996).

California Central Valley steelhead spawning occurs mainly in gravel substrates (particle size ranges from about 0.2 to 2.2 inches, Stanislaus River Scientific Evaluation Process (SEP) Team 2019). Adults tend to spawn in shallow areas (6 to 24 inches deep) with moderate water velocities (about 1 to 3.6 feet per second, Hannon and Deason 2008). Unlike Chinook salmon, CCV steelhead may not die after spawning (McEwan and Jackson 1996). Some may return to the ocean and repeat the spawning cycle for 2 or 3 years. The percentage of adults surviving

spawning is generally thought to be low for CCV steelhead but varies annually and between stocks. Acoustic tagging of CCV steelhead kelts from the Coleman Hatchery indicates survival rates can be high, especially for CCV steelhead reconditioned by holding and feeding at the hatchery prior to release. Some return immediately to the ocean and some remain and rear in the Sacramento River (Null et al. 2013). Studies have shown that kelts may remain in freshwater for an entire year after spawning (Teo et al. 2011) but that most return to the ocean (Null et al. 2013).

California Central Valley steelhead preferred water temperatures for spawning and egg incubation are approximately 39°F and 52°F, and egg mortality likely begins at 56°F, respectively (CDFG 1996, McEwan 2001, Reiser and Bjornn 1979). After hatching, the young fish (alevins) remain in the gravel for an extra 2 to 6 weeks before emerging from the gravel and taking up residence in the shallow margins of the stream. California Central Valley steelhead embryo incubation generally occurs from December through June in the Central Valley.

California Central Valley steelhead eggs reportedly have the highest survival rates at water temperature ranges of 44.6°F to 50.0°F (Myrick and Cech Jr 2001). A sharp decrease in survival has been reported for *O. mykiss* embryos incubated above 57.2°F (Kamler and Kato 1983). After hatching, alevins remain in the gravel for an additional 2 to 5 weeks while absorbing their yolk sacs and then emerge in spring or early summer (Barnhart 1986).

The newly emerged juveniles move to shallow, protected areas associated within the stream margin (McEwan and Jackson 1996). Productive juvenile rearing habitat is characterized by complexity, primarily in the form of cover, which can be deep pools, woody debris, aquatic vegetation, or boulders. Cover is an important habitat component for juvenile CCV steelhead both as velocity refugia and as a means of avoiding predation (Meehan and Bjornn 1991). Older juveniles use riffles and larger juveniles may also use pools and deeper runs (Barnhart [1986] as cited in McEwan and Jackson [1996]). However, specific depths and habitats used by juvenile rainbow trout can be affected by predation risk (Brown and Brasher 1995). An upper water temperature limit of 65°F is preferred for growth and development of Sacramento River and American River juvenile steelhead (National Marine Fisheries Service 2002, Bratovich et al. 2005) and temperatures below 60°F can reduce the risk of pathogen virulence for steelhead rearing and out-migration while still allowing for strong growth (McCullough 1999, Carter 2005).

Most juvenile CCV steelhead spend 1 to 3 years in fresh water before emigrating to the ocean as smolts (Shapovalov and Taft 1954). The primary period of CCV steelhead smolt out-migration from rivers and creeks to the ocean generally occurs from January to June (National Marine Fisheries Service 2009a). California Central Valley steelhead successfully smolt at water temperatures in the 43.7°F to 52.3°F range (Myrick and Cech Jr 2001). In the Sacramento River, juvenile CCV steelhead migrate to the ocean in spring and early summer at 1 to 3 years of age with peak migration through the Delta in March and April (Reynolds et al. 1993).

4.5.3. Viability Status and Trends

Good et al. (2005) found that the CCV steelhead DPS was in danger of extinction, with a minority of the Biological Review Team viewing the DPS as likely to become endangered. The Biological Review Team's major concerns were the low abundance of natural-origin

anadromous *O. mykiss*, the lack of population-level abundance data, and the lack of any information to suggest that the decline in CCV steelhead abundance evident from 1967 to 1993 dams counts had stopped.

Using data through 2005, Lindley et al. (2007) found that data were insufficient to determine the viability of any of the naturally-spawning populations of CCV steelhead, except for those spawning in rivers adjacent to hatcheries, which were likely to be at high risk of extinction due to extensive spawning of hatchery-origin fish in natural areas.

The proportion of hatchery-origin fish in the Battle Creek returns averaged 29 percent over the 2002–2010 period, elevating the level of hatchery influence to a moderate risk of extinction. The Chipps Island midwater trawl dataset of USFWS indicated that the decline in the natural production of CCV steelhead had continued unabated through 2010, with the proportion of adipose fin-clipped CCV steelhead reaching 95 percent. In 2015, population trend data showed significant increases in abundance of Coleman National Fish Hatchery and FRFH populations, but data are still lacking to estimate trends in natural populations.

The final Central Valley Salmon and Steelhead Recovery Plan (National Marine Fisheries Service 2014b) includes biological recovery criteria based on the VSP concept. The Central Valley Salmon and Steelhead Recovery Plan includes the following DPS-level recovery criteria:

- One population in the Northwestern California Diversity Group at low risk of extinction
- Two populations in the Basalt and Porous Lava Diversity Group at low risk of extinction
- Four populations in the Northern Sierra Diversity Group at low risk of extinction
- Two populations in the Southern Sierra Diversity Group at low risk of extinction
- Maintain multiple populations at moderate risk of extinction

In order to meet the recovery criteria for this DPS and thereby delist the species, there must be at least nine populations at a low risk of extinction distributed throughout the Central Valley as outlined above, as well as additional populations at a moderate risk of extinction (National Marine Fisheries Service 2014b). Currently, no CCV steelhead populations satisfy the low extinction risk criteria. For the 17 populations evaluated in the SWFSC's 2022 viability assessment, 11 are at high extinction risk and six are at moderate extinction risk (Johnson et al. 2023b). Twelve of the populations are at high or moderate extinction risk based on population size, indicating low abundance of natural-origin CCV steelhead (Johnson et al. 2023b).

4.5.4. Abundance and Productivity

Population trend data remain extremely limited for the CCV steelhead DPS. The total hatchery populations from Coleman National Fish Hatchery, FRFH, and Mokelumne River Hatchery have significantly increased since the 2010 and 2015 viability assessments. In fact, Coleman National Fish Hatchery returns have steadily increased 15 percent per year over the last decade.

The American River steelhead population has experienced a precipitous decline since 2003, resulting in a moderate risk of extinction. It should be noted that a significant proportion of steelhead redds on the American River are made by Nimbus Hatchery steelhead, which are not part of the DPS, and declined 8 percent per year over the last decade.

Looking broader than the individual population level, Chipps Island midwater trawl data provide information on the trend in abundance for the CCV steelhead DPS as a whole. Updated through 2019, the trawl data indicate that the production of natural-origin CCV steelhead remains very low relative to hatchery production. The lack of improved natural production as estimated by juvenile migrants exiting the river systems at Chipps Island and low abundances coupled with large hatchery influence is cause for concern.

Catch per unit effort has fluctuated and generally increased over the past decade, but the proportion of the catch that is adipose fin-clipped (100 percent of hatchery CCV steelhead production have been adipose fin-clipped starting in 1998) has increased steadily, exceeding 90 percent in recent years and reaching 96 percent during the drought in 2015. This suggests that the vast majority of CCV steelhead out-migrating from the Delta are of hatchery origin.

4.5.5. Spatial Structure and Diversity

This DPS includes CCV steelhead populations spawning in the Sacramento and San Joaquin rivers and their tributaries. Populations upstream of migration barriers remain excluded from this DPS. Hatchery stocks within the DPS include Coleman National Fish Hatchery, FRFH, and Mokelumne River Hatchery. Genetic analysis showed that the steelhead stock propagated in the Mokelumne River Hatchery was genetically similar to the steelhead broodstock in the FRFH (Pearse and Garza 2015), consistent with documentation on the recent transfers of eggs from the FRFH for broodstock at the Mokelumne River Hatchery. The Nimbus Hatchery steelhead remain genetically divergent from the Central Valley DPS lineages, consistent with their founding from coastal steelhead stocks, and remain excluded from the DPS (Pearse and Garza 2015).

As overall data remain extremely limited for the CCV steelhead DPS, it is difficult to ascertain if their spatial distribution has changed. From recent monitoring data, CCV steelhead are not noted to have had any substantial changes in spatial distribution or diversity. Hatchery influence continues to be a high threat to diversity of the DPS, and the out-of-basin stock at Nimbus Hatchery poses significant genetic threat to CCV steelhead (Johnson et al. 2023b).

4.5.6. Summary of the California Central Valley Steelhead Viability

Based upon the limited information available, the overall viability of the CCV Steelhead DPS appears to be unchanged since the NMFS' 2015 5-year review. However, the majority (11 of 16) of populations for which there are data are at a high risk of extinction based on abundance and/or hatchery influence, with no population considered to be at a low risk of extinction. The lack of improved natural production estimates and low abundances coupled with large hatchery influence are causes for continued concern (Johnson et al. 2023b).

4.5.7. Limiting Factors and Threats

Section 4 of the ESA requires the Secretary of the Interior or Commerce, depending upon the species involved, to determine if any species is an endangered or threatened species for any of the following listing factors: (1) present or threatened destruction, modification or curtailment of its habitat or range; (2) overutilization for commercial, recreational. scientific or educational purposes; (3) disease or predation; (4) inadequacy of existing regulatory mechanisms; or (5)

other natural or manmade factors affecting its continued existence. Each of these listing factors with respect to CCV steelhead are summarized below.

4.5.7.1. The Present or Threatened Destruction, Modification, or Curtailment of California Central Valley Steelhead's Habitat or Range

The widespread degradation, destruction, and blockage of freshwater habitats within the Central Valley and the continuing impacts to habitat resulting from water management were identified as key reasons why CCV steelhead were listed under the ESA (61 FR 41541 , 63 FR 13347). These reasons are briefly discussed below under two categories: habitat loss and habitat degradation.

Habitat Loss

About 80 percent of habitat identified by the Technical Recovery Team that was historically available to anadromous *O. mykiss* is now behind impassable dams, and 38 percent of the populations identified by the Technical Recovery Team have lost all of their habitat (Lindley et al. 2006). Anadromous *O. mykiss* populations may have been extirpated from their entire historical range in the San Joaquin Valley and most of the larger basins of the Sacramento River. The roughly 52 percent of watersheds with at least half of their historical area below impassable dams are all small, low elevation systems (Lindley et al. 2006).

Habitat Degradation

The habitat in the Central Valley that remains accessible to anadromous *O. mykiss* has been drastically altered and degraded. Reynolds et al. (1993) reported that declines in CCV steelhead stocks are "due mostly to water development, inadequate instream flows, rapid flow fluctuations, high summer water temperatures in streams immediately below reservoirs, diversion dams which block access, and entrainment of juveniles into unscreened or poorly screened diversions." Other problems related to land use practices (agriculture and forestry) and urbanization also have certainly contributed to the decline of CCV steelhead (McEwan 2001).

4.5.7.2. Overutilization of Steelhead for Commercial, Recreational, Scientific, or Educational Purposes

The overutilization of CCV steelhead was not identified as an important reason for the species' listing (61 FR 41541 , 63 FR 13347 1998).

Commercial or Recreational Fishery Impacts on California Central Valley Steelhead

Because there is no commercial fishery for CCV steelhead and the recreational fishery is regulated to protect wild CCV steelhead, there is some reason to think that fishing impacts would not be a significant problem for this species. However, because the sizes of CCV steelhead populations are largely unknown, it is difficult to make conclusions about the impact of the recreational fishery (Good et al. 2005).

Scientific or Educational Utilization of California Central Valley Steelhead

NMFS issues permits under the ESA for scientific research that stipulate specific conditions to minimize take of CCV steelhead. These permitted studies provide information about steelhead in

the Central Valley that is useful for management and conservation of the DPS and are not considered a factor for the decline of this species (National Marine Fisheries Service 2011a).

4.5.7.3. Disease or Predation

Disease

Infectious disease is one of many factors which can influence adult and juvenile CCV steelhead survival. California Central Valley steelhead are exposed to numerous bacterial, protozoan, viral, and parasitic organisms in spawning and rearing areas, hatcheries, migratory routes, and the marine environments. Specific diseases such as bacterial kidney disease, ceratomyxosis, columnaris, Furunculosis, infectious hematopoietic necrosis, redmouth and black spot disease, Erythrocytic Inclusion Body Syndrome, and whirling disease, among others, are present and are known to affect steelhead and salmon (National Marine Fisheries Service 1996).

Although disease was recognized as a potential factor in the decline of West Coast steelhead (National Marine Fisheries Service 1996), it was not specifically identified as an important reason why CCV steelhead were listed under the ESA (61 FR 41541 , 63 FR 13347).

4.5.7.4. The Inadequacy of Existing Regulatory Mechanisms

The inadequacy of existing regulatory mechanisms was not identified as a key factor in the listing of CCV steelhead. Although there is a lengthy discussion of this listing factor in the Final Rule listing CCV steelhead as threatened, most of the discussion applies to other steelhead ESUs, which were also considered for listing at that time (63 FR 13347).

4.5.7.5. Other Natural or Manmade Factors Affecting the Continued Existence of California Central Valley Steelhead

Hatchery Management/Reduced Genetic Integrity

Along with habitat loss and habitat degradation, hatchery management was identified as a key factor in the listing of CCV steelhead (61 FR 41541 , 63 FR 13347). Over the past several decades, the genetic integrity of CCV steelhead has been diminished by increases in the proportion of hatchery fish relative to naturally produced fish, the use of out-of-basin stocks for hatchery production, and straying of hatchery-produced fish (California Department of Fish and Game and National Marine Fisheries Service 2001, California Hatchery Scientific Review Group 2012). Four hatcheries in the Central Valley produce steelhead, and each hatchery has specific production targets. Currently there is still great concern about the ecological and genetic impacts of steelhead hatchery management in the Central Valley (California Hatchery Scientific Review Group 2012). These concerns continue to be related to the proportion of hatchery fish relative to naturally produced fish, the predominance of Eel River steelhead genetics in the Nimbus Hatchery steelhead program, and straying of hatchery-produced steelhead.

Potential adverse effects to wild CCV steelhead populations associated with hatchery production are similar to those described for SR winter-run Chinook salmon. Research has indicated that approximately 63 to 77 percent of CCV steelhead collected at a monitoring site in the Delta were

of hatchery origin (Good et al. 2005). Overall, hatchery-origin fish appear to comprise the majority of the DPS (Lindley et al. 2007).

Habitat fragmentation and population declines resulting in small, isolated populations also pose genetic risk from inbreeding, loss of rare alleles, and genetic drift. There is still significant local genetic structure to CCV steelhead populations. Hatchery effects appear to be localized—for example, Feather River and the FRFH steelhead are closely related, as are American River and Nimbus Hatchery fish (California Department of Fish and Game 1991, Brodsky et al. 2020). The Coleman National Fish Hatchery steelhead program was derived from the endemic stock of steelhead in the Upper Sacramento River. Early-returning (October–December) steelhead in Battle Creek are similar genetically to the Coleman National Fish Hatchery adults, and late-returning (March–May) natural origin steelhead in Battle Creek are similar genetically to mainstem Sacramento River steelhead (Campton et al. 2004).

In general, although genetic structure was found, all naturally-spawned *O. mykiss* populations within the Central Valley basin were closely related, regardless of whether they were sampled above or below a known barrier to anadromy. This is due to some combination of pre-impoundment historic shared ancestry, downstream migration, and, possibly, limited anthropogenic upstream migration. However, lower genetic diversity in above-barrier populations indicates a lack of substantial genetic input upstream and highlights lower effective population sizes for above-barrier populations. Above-barrier populations clustered with one another and below-barrier populations are most closely related to populations in far northern California, specifically the genetic groups that include the Eel and Klamath rivers. Since Eel River-origin broodstock were used for many years at Nimbus Hatchery on the American River, it is likely that Eel River genes persist there and have also spread to other basins by migration and that this is responsible for the clustering of the below-barrier populations with northern California ones. This suggests that the below-barrier populations in this region appear to have been widely introgressed with hatchery fish from out-of-basin broodstock sources. The consistent clustering of the above-barrier populations with one another and their position in the California-wide trees indicate that they are likely to most accurately represent the ancestral population genetic structure of steelhead in the Central Valley (Garza et al. 2008).

A significant transfer of genetic material has occurred among hatcheries within the Central Valley, as well as some transfer from systems outside the Central Valley. For example, an Eel River strain of steelhead was used as the founding broodstock for the Nimbus Hatchery (California Department of Fish and Game 1991, Brodsky et al. 2020). Additionally, eyed eggs from the Nimbus Hatchery were transferred to the FRFH several times in the late 1960s and early 1970s (California Department of Fish and Game 1991, Brodsky et al. 2020). There have also been transfers of steelhead from the FRFH to the Mokelumne Hatchery. In the late 1970s, a strain of steelhead was brought in from Washington State for the FRFH (California Department of Fish and Game 1991, Brodsky et al. 2020).

Environmental Variability

Variability in natural environmental conditions has both masked and exacerbated the problems associated with degraded and altered riverine and estuarine habitats. Floods and persistent drought conditions have periodically reduced CCV steelhead spawning, rearing, and migration habitats.

El Nino events and periods of poor ocean conditions can threaten the survival of CCV steelhead populations already reduced to low abundance levels due to the loss and degradation of freshwater and estuarine habitats. Alternatively, periods of favorable ocean conditions can offset the poor condition of inland habitats and result in increased population abundance and productivity by increasing the size and correlated fecundity of returning adults (National Marine Fisheries Service 1996).

4.5.8. Recovery Priorities

NMFS is directing our CCV steelhead recovery efforts at populations that need viability improvement according to DPS-, Diversity Group-, and population-level recovery criteria; the best available scientific information concerning DPS status; the role of the independent populations in meeting DPS and Diversity Group viability; limiting factors and threats; and the likelihood of action effectiveness to guide our recommendations for future actions. NMFS is coordinating with the federal, state, tribal, and local implementing entities to ensure that risk factors and actions are addressed that were identified in the Central Valley Salmon and Steelhead Recovery Plan (National Marine Fisheries Service 2014b) and the actions identified in the 2019 BA (U.S. Bureau of Reclamation 2019b), 2019 Biological Opinion (National Marine Fisheries Service 2019b), 2020 ITP, Yuba Reintroduction Working Group, San Joaquin River Restoration Program, and others.

The greatest opportunities to advance CCV steelhead recovery are to:

- Complete the Battle Creek Restoration Project and implement the full restoration flows.
- Conduct additional research to understand the extent to which genes associated with the heritable components of anadromy could be lost from *O. mykiss* populations with low steelhead numbers, thus placing steelhead at a greater risk of extinction (Pearse et al. 2019). One of the greatest challenges in managing for resilient steelhead populations in regulated Central Valley rivers lies in understanding how water project operations and related changes to habitats and ecosystems promote, maintain, or suppress the expression and survival of the anadromous life history form of *O. mykiss*.
- Implement the 2019 Biological Opinion's Steelhead Monitoring Program (National Marine Fisheries Service 2019b). Conduct CCV steelhead life cycle monitoring in designated watersheds. This monitoring should be directed at the goal of developing overall abundance and ideally be able to help determine population viability for CCV steelhead populations with unknown viability.
- CCV steelhead hatchery managers should consider the management actions identified in Huber et al. (2024) and implement actions to improve the biocomplexity and stability of CCV steelhead.
- Ensure that Central Valley steelhead hatcheries secure required HGMPs and collect a full set of biological data, including scale samples, length, weight, sex, origin, and state of maturity, from a subset of all returning fish. Study hatchery smolt survival using modern tagging methods, such as PIT tags and/or acoustic tags. Standardize the terminology used among hatcheries to report different life history forms.
- Investigate the development of non-lethal methods to determine the life history of individual *O. mykiss*.

    - The management of steelhead in the Central Valley is currently hampered by the inability to conclusively determine if individual fish have made an ocean migration and are steelhead protected under the ESA.
- Reintroduce CCV steelhead to historical spawning and rearing habitats in the McCloud River, the upper Yuba River watershed, and the upper sections of the Stanislaus, Tuolumne, and/or Merced rivers.

4.5.9. Recovery Plan Core Classifications and Primary Reintroduction Areas

The NMFS Recovery Plan for Central Valley Salmon and Steelhead (National Marine Fisheries Service 2014b) developed watershed classifications to assess the potential for populations to contribute to species recovery. There are three categories: Core 1, Core 2, and Core 3. The NMFS Recovery Plan for Central Valley Salmon and Steelhead also identifies primary, candidate, and non-candidate watersheds for reintroduction to historic habitats. Primarily reintroduction watersheds have the highest reintroduction priority.

- Core 1 populations meet or have the potential to meet the long-term objective of low extinction risk. These populations possess the known ability or potential ability to support a viable population.
- Core 2 populations meet or have the potential to meet the biological recovery criteria for a moderate risk of extinction. These populations have lower potential to support viable populations due to lower abundance or amount and quality of habitat. They can contribute to increased diversity for a species and may provide resilience from catastrophic events that impact other populations.
- Core 3 populations are present in watersheds on an intermittent basis and require straying from other populations for their existence. They can contribute to increased diversity for a species and may provide resilience from catastrophic events that impact other populations.

California Central Valley steelhead occur across four diversity groups in the Central Valley: the Basalt and Porous Lava Diversity Group, the Northwestern California Diversity Group, the Northern Sierra Diversity Group, and the Southern Sierra Diversity Group.

Basalt and Porous Lava Diversity Group - The following Core classifications and primary reintroduction watersheds are identified in the NMFS Recovery Plan for Salmon and Steelhead:

- Core 1: Battle Creek
- Core 2: Cow Creek and Mainstem Sacramento River
- Core 3: There are no Core 3 populations in this diversity group
- Primary reintroduction watershed: McCloud River

Northwestern California Diversity Group - The following Core classifications and primary reintroduction watersheds are identified in the NMFS Recovery Plan for Salmon and Steelhead:

- Core 1: Clear Creek
- Core 2: Cottonwood/Beegum, Thomes, and Putah creeks
- Core 3: Stony Creek
- There are no primary reintroduction watersheds in this diversity group

Northern Sierra Nevada Diversity Group - The following Core classifications and primary reintroduction watersheds identified in the NMFS Recovery Plan for Salmon and Steelhead:

- Core 1: Antelope, Deer, and Mill creeks
- Core 2: Big Chico and Butte creeks; Feather, Yuba, American, and Mokelumne rivers; and Auburn Ravine
- Core 3: Bear and Cosumnes rivers
- Primary reintroduction watersheds: Yuba River

Southern Sierra Nevada Diversity Group - The following Core classifications and primary reintroduction watersheds are identified in the NMFS Recovery Plan for Salmon and Steelhead:

- Core 1: Calaveras River
- Core 2: Stanislaus, Tuolumne, and Merced rivers
- Core 3: There are no Core 3 populations in this diversity group
- Primary reintroduction watersheds: There are no primary reintroduction watersheds in this diversity group

4.5.10. Climate Change

In California, there have been observed changes in air temperatures, annual precipitation, runoff, and sea levels over the past century (Anderson et al. 2008). Regional-scale climate models for California are in broad agreement that temperatures in the future will warm significantly, total precipitation may decline, and snowfall will decline significantly (Lindley et al. 2007). Literature suggests that by 2100, mean summer temperatures in the Central Valley may increase by 2°C to 8°C, precipitation will likely shift to more rain and less snow, with significant declines in total precipitation possible, and hydrographs will likely change, especially in the southern Sierra Nevada mountains. Thus, climate change poses an additional risk to the survival of salmonids in the Central Valley. As with their ocean phase, CCV steelhead will be more thermally stressed by stream warming at the southern ends of their ranges (e.g., Central Valley domain).

CCV steelhead exhibit a flexible life history, allowing them to compensate for the variable conditions and extremes of their habitat (McEwan 2001). Most juveniles remain in streams for 1 or 2 years before becoming smolts and emigrating out to the Delta and ocean (Hallock et al. [1961] in Schwing [2009]). Others may remain in the rivers their entire lives. Temperature and water quality are critical factors for fry and juvenile survival (Moyle 2002). Fry move into cooler, deeper, faster-flowing channels in the late summer and fall (Hartman 1965, Everest and Chapman 1972, and Fontaine 1988, as cited in Schwing [2009]). Juvenile steelhead prefer deep pools with heavy cover, as well as higher-velocity rapids (Bisson and Bilby 1982, Bisson et al. 1988, Dambacher 1991, as cited in Schwing 2009).

The distribution of CCV steelhead today is greatly reduced from the historical distribution. Dams and water diversions limit CCV steelhead access to less than 20 percent of their historical spawning and rearing areas in the Central Valley (Yoshiyama et al. 2001, Lindley et al. 2006). Climate warming will further restrict access to cool water streams. The diversity and variability of their life history complicates their management, yet this same attribute reduces their vulnerability to climate change.

Additionally, low flows during juvenile rearing and out-migration are associated with poor survival through the Delta (Kjelson and Brandes 1989, Baker P.F. and Morhardt 2001, Newman and Rice 2002) and poor returns in subsequent years (Speed 1993). Climate change also may impact Central Valley salmonids through community effects. For example, warming may increase the activity and metabolic demand of predators, reducing the survival of juvenile salmonids (Vigg and Burley 1991).

Based upon the limited information available, the overall viability of the CCV steelhead DPS appears to be unchanged since the NMFS 5-year review (NMFS 2016a). However, the majority (11 of 16) of populations for which data exists are at a high risk of extinction based on abundance and/or hatchery influence. No population is currently considered to be at a low risk of extinction. The lack of improved natural production estimates, and low abundances coupled with large hatchery influence are causes for continued concern (National Marine Fisheries Service 2023d).

4.6. Designated Critical Habitat for California Central Valley Steelhead

The geographical extent of designated critical habitat includes, but is not limited to, the following: Sacramento, Feather, and Yuba rivers; Clear, Deer, Mill, Battle, and Antelope creeks in the Sacramento river basin; the San Joaquin River, including its tributaries; and the waterways of the Delta (Figure 12). With the exception of Clifton Court Forebay, the entirety of the proposed action area in the Central Valley is designated critical habitat for CCV steelhead.



Figure 12. Designated critical habitat for the California Central Valley steelhead Distinct Population Segment.

The critical habitat for CCV steelhead lists the essential PBFs (70 FR 52488, September 2, 2005), which include:

1. Freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, incubation, and larval development

2. Freshwater rearing sites with (i) water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; (ii) water quality and forage supporting juvenile development; and (iii) natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks

3. Freshwater migration corridors free of obstruction and excessive predation with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival

4. Estuarine areas free of obstruction and excessive predation with: (i) water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between freshwater and saltwater; (ii) natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels; and (iii) juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation

Historically, CCV steelhead spawned in many of the headwaters and upstream portions of the Sacramento River and San Joaquin river basin. Similar to SR winter-run Chinook salmon, passage impediments have contributed to substantial reductions in the populations of these species by isolating them from much of their historical spawning habitat. California Central Valley steelhead spawn in the upper accessible Sacramento River and Clear Creek, as well as throughout the Lower American River between its confluence with the Sacramento River up to Nimbus Dam. The PBFs of freshwater spawning sites have been degraded within the action area due to high water temperatures, redd dewatering, and loss of spawning gravel recruitment in reaches below Keswick Dam (Wright and Schoellhamer 2004, Good et al. 2005, National Marine Fisheries Service 2009a, Jarrett and Killam 2014). These issues are actively addressed by adaptive flow management in both rivers as well as spawning gravel augmentation projects in both reaches.

Freshwater rearing and migration PBFs have been degraded from their historical condition within the action area. In the Sacramento and San Joaquin rivers, bank armoring has significantly reduced the quantity of floodplain rearing habitat for juvenile salmonids and has altered the natural geomorphology of the river (National Marine Fisheries Service 2014b). Similar to SR winter-run Chinook salmon, CCV steelhead are only able to access large floodplain areas, such as the Yolo Bypass, under certain hydrologic conditions which do not occur in drier years. The Yolo Bypass Restoration Salmonid Habitat Restoration and Fish Passage Implementation Plan includes notching the Fremont Weir, which will provide access to floodplain habitat for juvenile CCV steelhead over a longer period (California Department of Water Resources and U.S. Bureau of Reclamation 2016). Levee construction involves the removal of riparian vegetation, resulting

in reduced habitat complexity and shading, making juveniles more susceptible to predation. Additionally, loss of riparian vegetation reduces aquatic macroinvertebrate recruitment, resulting in decreased food availability for rearing juveniles (Anderson and Sedell 1979, Pusey and Arthington 2003).

The Lower American River has experienced similar losses of rearing habitat. Projects sponsored by Reclamation are restoring rearing habitat for juvenile CCV steelhead through the creation of side channels and placement of instream woody material (U.S. Bureau of Reclamation 2015).

Although the current conditions of CCV steelhead critical habitat are significantly degraded, the spawning habitat, migratory corridors, and rearing habitat that remain in the Sacramento-San Joaquin River watershed and the Delta are considered to have high intrinsic value for the conservation of the species as they are critical to ongoing recovery efforts.

4.7. Southern Distinct Population Segment of Green Sturgeon

4.7.1. Introduction and Background

North American green sturgeon include a Northern DPS consisting of populations originating from coastal watersheds northward of and including the Eel River (i.e., the Klamath and Rogue rivers) and a Southern DPS consisting of populations originating from coastal watersheds south of the Eel River, with the only known spawning population in the Sacramento River Basin (74 FR 52300, October 9, 2009).

4.7.1.1. Listing Classification and Date

The sDPS of green sturgeon was listed as a threatened species under the ESA on April 7, 2006 (71 FR 17757, Table 14). The Northern DPS is not listed under the ESA. NMFS designated critical habitat for the sDPS green sturgeon on October 9, 2009 (74 FR 52300), as well as an updated ESA 4(d) ruling publishing final ESA protective regulations on June 2, 2010 (75 FR 30714).

Table 14. Summary of the listing history under the Endangered Species Act for the Southern Distinct Population Segment of green sturgeon.

Sturgeon Species	ESU/DPS Name	Original Listing	Revised Listing(s)	Critical Habitat Designation
Green Sturgeon (*A. medirostris)*	Southern Distinct Population Segment of North American green sturgeon	**FR notice:** 71 FR 17757 **Date:** April 7, 2006 **Classification:** Threatened	**FR notice:** 75 FR 30714 **Date:** June 2, 2010 **Classification:** ESA 4(d) rule	**FR notice:** 74 FR 52300 **Date:** October 9, 2009 **Classification:** Critical habitat designation

4.7.1.2. Recovery Plan and Five-Year Reviews

On July 29, 2015, NMFS published a 5-year review for the sDPS green sturgeon which concluded that the status of the sDPS green sturgeon should remain "threatened" (National Marine Fisheries Service 2015a). NMFS finalized a Recovery Plan for sDPS green sturgeon with strategies and actions to support recovery of the species on August 8, 2018 (National Marine Fisheries Service 2018e).

The most recent 5-year review was published on October 26, 2021, which determined no change to the species status (National Marine Fisheries Service 2021a).

4.7.2. Population Structure

The California Central Valley green sturgeon includes the genetically isolated sDPS that naturally spawns within the Sacramento River and its tributaries (71 FR 17757). This listing does not include the Northern DPS of green sturgeon that spawn north of the Russian River. The sDPS of green sturgeon are genetically unique from the Northern DPS due to their isolated breeding behavior endemic solely to the Sacramento river basin. The sDPS of green sturgeon is composed of a single, independent population, which principally spawns in the mainstem Sacramento River (Israel et al. 2009), though spawning has now been documented in both the Feather and Yuba rivers as well (National Marine Fisheries Service 2018e).

4.7.3. Life History

The sDPS of green sturgeon enter the San Francisco Bay Delta Estuary in late winter/early spring and migrate upstream to their spawning grounds in the Sacramento, Feather, and Yuba rivers. Since sDPS green sturgeon spawn during the summer months (from late April through late July, peaking in May), mature adults must reach upper areas of the Sacramento river basin where cooler temperatures persist during the hottest months (Moser and Lindley 2007). The sDPS of green sturgeon predominantly spawn between (1) the Glenn-Colusa Irrigation Dam area (river kilometer 332.5) to Cow Creek (river kilometer 451) on the Sacramento River, (2) from the Fish Barrier Dam (river kilometer 108.5) to the Thermalito Afterbay Outlet (river kilometer 109) on the Feather River, and (3) at the base of the Daguerre Point Dam (river kilometer 19) on the Yuba River (National Marine Fisheries Service 2018e).

The eggs require water temperatures around 15°C (59°F) to hatch successfully, and within 10 days the larvae will hatch and rapidly move downstream. It is unknown how long juveniles remain in upriver rearing habitats after metamorphosis. Based on length distribution data from salvage and recent upstream surveys, juveniles typically enter the Delta as sub-yearlings or yearlings to rear prior to ocean entry (National Marine Fisheries Service 2018e). After reaching sub-adult sizes (approximately 91 centimeters), sDPS green sturgeon will migrate into the ocean, traveling along the North American West Coast for up to 15 years or until they reach sexual maturity (Erickson and Hightower 2007, Lindley et al. 2008, Lindley et al. 2011). Adult sDPS green sturgeon will spawn every 2 to 6 years on average, with higher returns upriver during high precipitation years (Benson et al. 2007, Erickson and Webb 2007, Heublein et al. 2009, Poytress et al. 2011, 2012).

4.7.4. Viability Status and Trends

Although McElhany et al. (2000) specifically addresses viable populations of salmonids, the science behind the concepts and viability parameters is applicable to sDPS green sturgeon. Since there were no reliable estimates of historical or current sDPS green sturgeon abundance, adult abundance criteria were developed using the best available information from general principles in conservation biology relating population viability to abundance (National Marine Fisheries Service 2018e). Multiple monitoring methods are needed to track sDPS green sturgeon spawning populations into the future, including continued annual DIDSON surveys, egg mat surveys, subsampling of adult population for individual health, and acoustic tagging efforts.

4.7.4.1. Spatial Structure and Diversity

All sDPS green sturgeon spawn within the Sacramento river basin. There is not enough scientific evidence to distinguish individual spawning subgroups within the basin. In general, sub-adult (from the age of ocean entry to age of first spawning) and adult North American green sturgeon spend most of their lives in oceanic environments where they occupy nearshore coastal waters from the Bering Sea, Alaska (Colway and Stevenson 2007) to Baja California, Mexico (Rosales-Casián and Almeda-Jauregui 2009). Telemetry data and genetic analyses suggest that sDPS green sturgeon generally occur from Graves Harbor, Alaska to Monterey Bay, California (Moser and Lindley 2007, Lindley et al. 2008, Lindley et al. 2011), traversing depths shallower than 110 meters (Erickson and Hightower 2007).

The rapid anthropomorphic shifting in Californian landscape from wetland to agriculture in the early 20th century likely had a negative impact on sDPS green sturgeon numbers. Historical sDPS green sturgeon spawning habitat may have extended up into the three major branches of the Upper Sacramento River above the current location of Shasta Dam—the Little Sacramento River, the Pit River, and the McCloud River (National Marine Fisheries Service 2009a). Additional spawning habitat is believed to have once existed above the current location of Oroville Dam on the Feather River (National Marine Fisheries Service 2009a). According to NMFS (2009a), the reduction of sDPS green sturgeon spawning habitat into one reach on the Sacramento River between Keswick Dam and Hamilton City has increased the vulnerability of this spawning population to catastrophic events.

Successful spawning of sDPS green sturgeon in other accessible habitats in the Central Valley (i.e., the Feather and Yuba rivers) is limited, in part, by late spring and summer warm water temperatures and water flow. Similar to salmonids in the Central Valley, sDPS green sturgeon spawning in the major lower river tributaries to the Sacramento River are likely to be further limited if water temperatures increase over time. Dams and other barriers causing fragmentation and blocking access to suitable spawning grounds for migrating sturgeon is the leading threat in the decline of many sturgeon populations (Rochard et al. 1990, Auer 1996). Since 2014, NMFS has specifically identified the Daguerre Point Dam on the Yuba River and Sunset Pumps boulder weir on the Feather river as key barriers limiting sDPS green sturgeon recovery.

The VSP concept identifies a variety of traits that exhibit diversity within and among populations, and this variation has important effects on population viability (McElhany et al. 2000). For the sDPS of green sturgeon, such traits include, but are not limited to: fecundity, age

at maturity, physiology, and genetic characteristics. Spawning habitat is used as a proxy for diversity because diversity is closely tied with abundance, distribution, and productivity.

Within the sDPS of green sturgeon, diversity is not yet well documented. Little is known about how current levels of diversity (e.g., genetic, life history) compare with historical levels. Further inquiry is needed to determine what, if any, genetic separation exists between those fish spawning within the Sacramento River and those spawning elsewhere. Since the previous review, available spawning habitat has not increased; therefore, the recovery criteria of "no net loss in diversity" was not met.

4.7.4.2. Abundance and Productivity

Recovery criteria for abundance requires the adult sDPS green sturgeon census population to remain at or above 3,000 for three generations (this equates to a yearly running average of at least 813 spawners for approximately 66 years). In addition, the effective population size must be at least 500 individuals in any given year and each annual spawning run must comprise a combined total, from all spawning locations, of at least 500 adult fish in any given year.

Due to sparse monitoring data for juvenile, sub-adult, and adult life stages in the Sacramento River and Delta, there are significant data gaps to describe the ecology of this species throughout their distribution range. Juveniles have been detected in the rivers on a yearly basis, with fluctuations of captured juveniles highly dependent upon water years (Thomas et al. 2014, Poytress et al. 2015, Mora et al. 2018). In late 2023 and early 2024, seven juvenile sDPS green sturgeon were found entrained in irrigation canals upstream of Wallace Weir, suggesting higher levels of entrainment in juvenile sDPS green sturgeon than previously assumed.

Yearly returns were calculated from 2007 to 2018, and no significant change in abundance trends has been determined for the population as a whole. Yearly adult spawner return estimates fluctuate between 336 to 1,236 individuals dependent upon annual precipitation percentages, for example, with wetter years being generally associated with higher returns (Mora et al. 2018).

The NMFS 2021 5-year review concluded that no abundance and productivity-related recovery criteria have been met (National Marine Fisheries Service 2021a). The estimated total population of sDPS green sturgeon is 17,548 individuals, with an estimated 2,106 adults (Mora et al. 2018). Therefore, the adult population does not meet the criteria of a yearly average of 3,000 adults. Reported annual spawner counts have also been less than 500 in the Sacramento River (Mora et al. 2018). Currently, there are no reliable estimates for spawner counts for the Feather and Yuba rivers.

The parameters of sDPS green sturgeon population growth rate and carrying capacity in the Sacramento Basin are poorly understood. Larval count data from incidental bycatch in rotary screw traps collected since the mid-1990s at Red Bluff Diversion Dam and near the Glenn Colusa Irrigation District diversion show enormous variability between years. The highest count and density on record was over 30 sDPS green sturgeon per acre-feet of water volume sampled at Red Bluff in 2016, an order of magnitude higher than other years (U.S. Fish and Wildlife Service 2016b). In general, sDPS green sturgeon year class strength appears to be highly variable, with overall abundance dependent upon a few successful spawning events (75 FR 30714 2010). Other

indicators of productivity, such as data for cohort replacement ratios and spawner abundance trends, are not currently available for sDPS green sturgeon.

4.7.5. Recovery

4.7.5.1. Limiting Factors and Threats

The major limiting factors that currently impede sDPS green sturgeon recovery are as follows: (1) the mainstem Sacramento River contains the only known annual sDPS green sturgeon spawning population, with infrequent spawning on the Feather and Yuba rivers based on annual water conditions (annual spawning levels below demographic recovery goals); (2) there has been a substantial loss of spawning habitat in the upper Sacramento and Feather rivers; (3) the Sacramento River and Delta face mounting threats to habitat quality and quantity; and (4) fishery-independent data indicated a decrease in observed numbers of juvenile sDPS green sturgeon collected (National Marine Fisheries Service 2018e). These limiting factors are directly influenced by various threat categories affecting sDPS green sturgeon throughout their range. The 2021 5-year review analyzed the five major threat-based recovery criteria to sDPS green sturgeon: (1) altered habitat, (2) overutilization, (3) disease/predation, (4) inadequacy of regulatory mechanisms, and (5) other natural/man-made factors (National Marine Fisheries Service 2021a). There has been no change in the analysis of these threat-based recovery criteria from the previous 5-year review, and none of the threat-based recovery criteria have been met.

Indirect anthropogenic actions have also provided significant limiting factors to sDPS green sturgeon recovery. Unintentional introduction of nonnative mollusc, shrimp, and fish species have altered the prey base in all life stages of sDPS green sturgeon, with many of these nonnative organisms providing less nutritional value for sDPS green sturgeon than native invertebrate and vertebrate species. Increased water temperatures and altered flow rates allow for increased proliferation of pathogens, diseases, and harmful algae in natal rivers, the central California delta, and coastal bays and estuaries along the west coast. Bycatch rates of sub-adult marine based green sturgeon in west coast groundfish fisheries remains high, with an estimated 20 percent post-release mortality rate based on tagging data (Richerson et al. 2022).

4.7.5.2. Recovery Goals and Criteria

There are five criteria for recovery stated in the sDPS green sturgeon 5-year review, and each criterion is determined by successful goal parameters met on a yearly basis (National Marine Fisheries Service 2018e, 2021a): (1) adult population yearly average of 3,000 mature adults, with 500 spawners present in the rivers in any given year for at least 66 years; (2) yearly successful spawning in at least two rivers within their historical range, determined by consistent presence of larvae for at least 20 years; (3) a net positive trend in juvenile and sub-adult abundance for at least 20 years; (4) a population characterized by a broad distribution of class sizes representing multiple cohorts that are stable over the long term for at least 20 years; and (5) no net loss of sDPS green sturgeon diversity from current levels. As of 2023, these criteria have not been met on a yearly basis, reaffirming that the status of sDPS green sturgeon remains listed under the ESA as threatened.

Recovery plan actions and research priorities were developed in order to reach the recovery criteria listed above and organized within the Green Sturgeon Recovery Plan (National Marine

Fisheries Service 2018e). Each action and research priority are defined as follows: Priority 1: an action that must be taken to prevent extinction or to identify those actions necessary to prevent extinction; Priority 2: an action that must be taken to prevent a significant decline in population numbers, habitat quality, or other significant negative impacts short of extinction; and Priority 3: all other actions necessary to provide for full recovery of the species (National Marine Fisheries Service 2018e). Each action and research priority identified falls into six threat categories concerning passage, water flow and temperature, entrainment, take, contaminants, and climate change. Undertaking actions in these areas is expected to have the biggest impact in terms of sDPS green sturgeon recovery (National Marine Fisheries Service 2018e).

4.7.5.3. Climate Change

Threats from altered trends in environmental conditions due to climate change are considered "high" or "very high" in many criteria involved with sDPS green sturgeon recovery. These trends include, but are not limited to: (1) changes in flow rates from varying yearly precipitation levels; (2) salinity intrusion into freshwater habitats from rising sea levels (projected 33 percent increase in the 21st century); (3) loss in habitat due to various environmental/anthropogenic factors; (4) altered prey base due to shifting habitat conditions; (5) increased water temperatures from higher frequencies of dry years, reduced spring snowpack, and reduced spring flows; (6) increased threat from harmful algal blooms within the San Francisco Bay Delta Estuary and Sacramento-San Joaquin inland delta; and (7) other altered environmental characteristics from increased/continued anthropogenic actions (Knowles and Cayan 2002, CH2M HILL 2014, National Marine Fisheries Service 2018e, 2021a). Further studies are needed to understand the trends in changing environmental conditions in order to determine best managerial practices for the future.

4.7.6. Summary

Evaluation of new information during the most recent 5-year status review did not suggest a significant change in the status of sDPS green sturgeon; therefore, NMFS concluded that the sDPS of green sturgeon remains at a moderate to high risk of extinction (National Marine Fisheries Service 2021a). Recovery criteria for sDPS green sturgeon have not been met on a yearly basis as of the latest 5-year review, and the fact that the vast majority of sDPS green sturgeon spawning occurs in the mainstem Sacramento River leaves the species highly susceptible to catastrophic events during spawning season.

The sDPS of green sturgeon remains at substantial risk of future population declines (National Marine Fisheries Service 2021a). The principal threat to green sturgeon in the sDPS is the reduction in available spawning habitat due to the construction of barriers on Central Valley rivers. The potential threats faced by sDPS green sturgeon include enhanced vulnerability due to the reduction of spawning habitat into one concentrated area on the Sacramento River, lack of good empirical population data, vulnerability of long-term cold water supply for egg incubation and larval survival, loss of juvenile sDPS green sturgeon due to entrainment at the project fish collection facilities in the South Delta and agricultural diversions within the Sacramento River and the Delta, alterations of food resources due to changes in the Sacramento River and Delta habitats, and exposure to various sources of contaminants throughout the basin to juvenile, sub-adult, and adult life stages.

Viability is defined as an independent population having a negligible risk of extinction due to threats from demographic variation, local environmental variation, and genetic diversity changes over a 100-year timeframe (McElhany et al. 2000). Evaluation of new information during the most recent 5-year status review did not suggest a significant change in the status of Southern DPS green sturgeon, therefore NMFS concluded that the sDPS of green sturgeon remains at a moderate to high risk of extinction (National Marine Fisheries Service 2021a).

4.8. Designated Critical Habitat for Southern Distinct Population Segment of Green Sturgeon

Critical habitat for sDPS green sturgeon is contained in nearly all of the proposed action's action area for listed anadromous fish with the exception of Clear Creek, the Lower American River from the SR-160 bridge upstream to Nimbus Dam, and the Stanislaus River. The geographical range of designated critical habitat includes the following:

- In freshwater, the geographic range includes:
    - The Sacramento River from the Sacramento I-Street Bridge to Keswick Dam, including the Sutter and Yolo bypasses and the Lower American River from the confluence with the mainstem Sacramento River upstream to the highway 160 bridge
    - The Feather River from its confluence with the Sacramento River upstream to the Fish Barrier Dam
    - The Yuba River from the confluence with the Feather River upstream to Daguerre Point Dam
    - The Sacramento-San Joaquin Delta (as defined by California Water Code section 12220, except for listed excluded areas)
- In coastal bays and estuaries, the geographical range includes:
    - San Francisco, San Pablo, Suisun, and Humboldt bays in California
    - Coos, Winchester, Yaquina, and Nehalem bays in Oregon
    - Willapa Bay and Grays Harbor in Washington
    - The lower Columbia River estuary from the mouth to river mile 46

In coastal marine waters, the geographic range includes all United States coastal marine waters out to the 60-fathom-depth bathymetry line, from Monterey Bay, California, north and east to include the Strait of Juan de Fuca, Washington (Figure 13 and Figure 14).

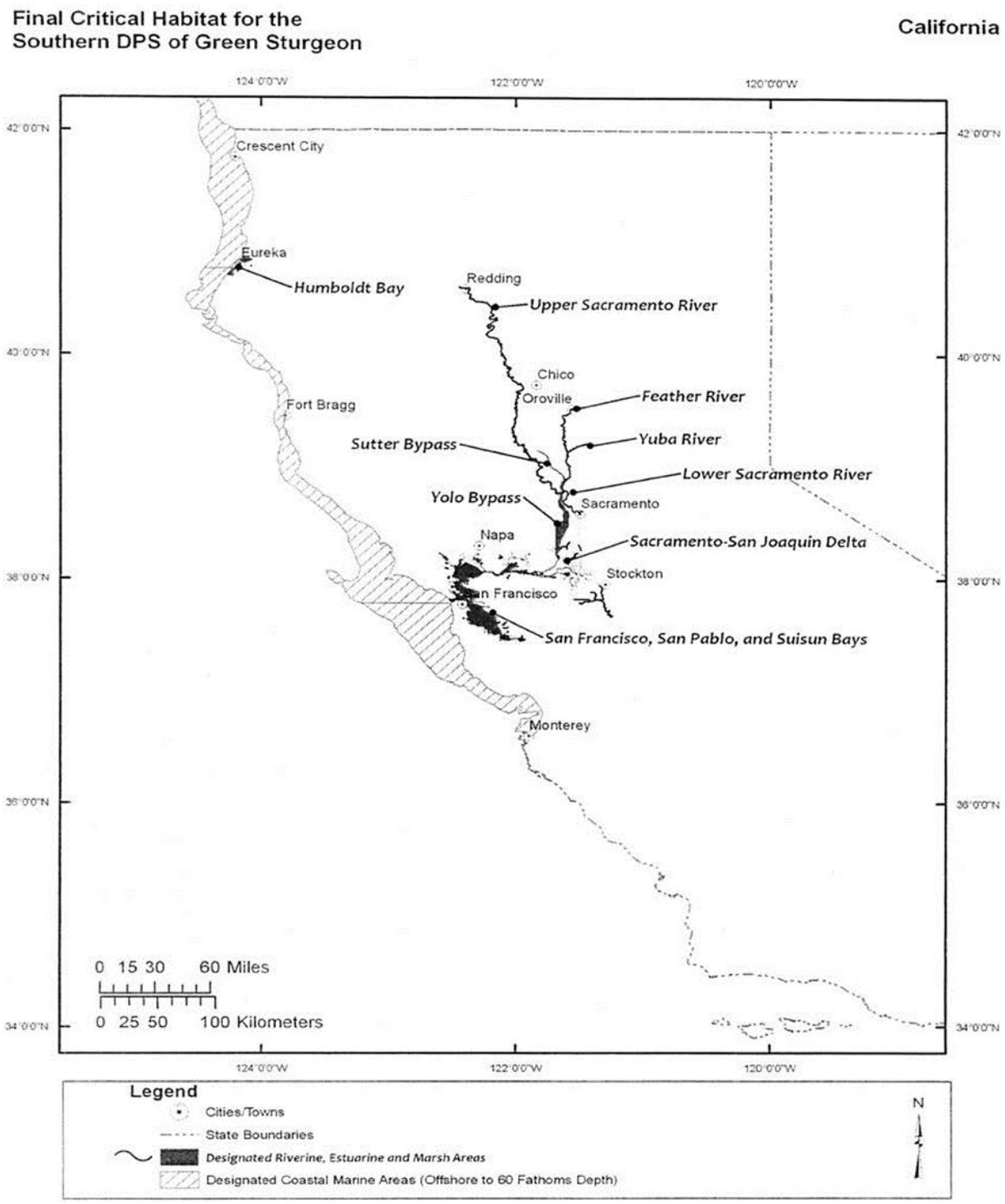


Figure 13. Designated critical habitat for Southern Distinct Population Segment green sturgeon in California.

Source: (74 FR 52300, October 9, 2009)

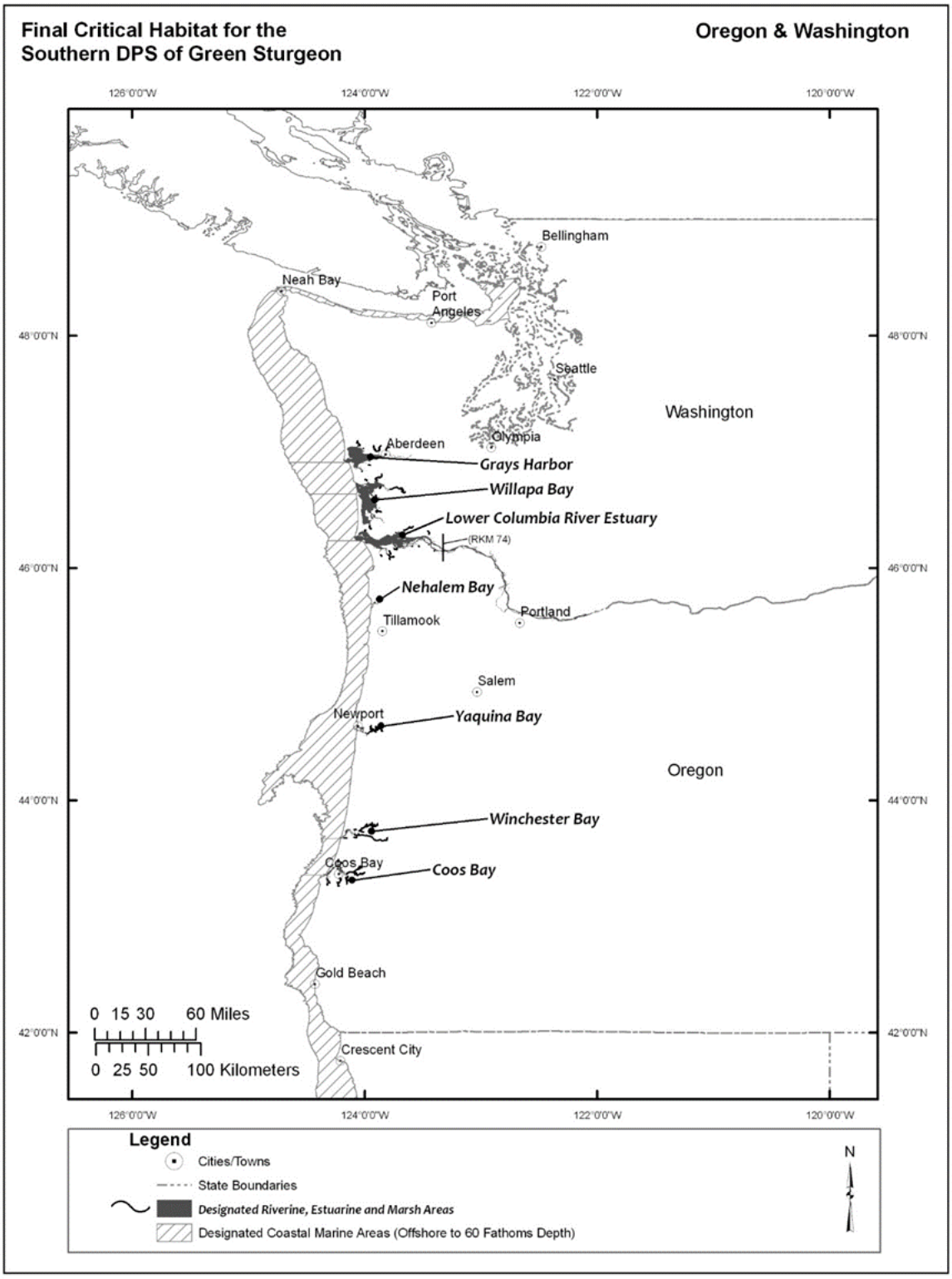


Figure 14. Designated critical habitat for Southern Distinct Population Segment green sturgeon in Oregon and Washington.

The designated critical habitat for sDPS green sturgeon lists the essential PBFs (74 FR 52300, October 9, 2009), which include the following for freshwater riverine and estuarine habitats:

Freshwater Riverine Habitats:

1) Food resources. Abundant prey items for larval, juvenile, subadult, and adult life stages.

2) Substrate type or size (i.e., structural features of substrates). Substrates suitable for egg deposition and development (e.g., bedrock sills and shelves, cobble and gravel, or hard, clean sand, with interstices or irregular surfaces to "collect" eggs and provide protection from predators, and free of excessive silt and debris that could smother eggs during incubation), larval development (e.g., substrates with interstices or voids providing refuge from predators and from high water flow), and feeding of juveniles, subadults, and adults (e.g., sand/mud substrates).

3) Water flow. A flow regime (i.e., the magnitude, frequency, duration, seasonality, and rate-of-change of fresh water discharge over time) necessary for normal behavior, growth, and survival of all life stages.

4) Water quality. Water quality, including temperature, salinity, oxygen content, and other chemical characteristics necessary for normal behavior, growth, and viability of all life stages.

5) Migratory corridor. A migratory pathway necessary for the safe and timely passage of all life stages within riverine habitats and between riverine and estuarine habitats (e.g., an unobstructed river or dammed river that still allows for safe and timely passage).

6) Depth. Deep (greater than or equal to five meters) holding pools for both upstream and downstream holding of adult or subadult fish with adequate water quality and flow to maintain the physiological needs of the holding adult or subadult fish.

7) Sediment quality. Sediment quality (i.e., chemical characteristics) necessary for normal behavior, growth, and viability of all life stages.

Estuarine Habitats:

1) Food resources. Abundant prey items within estuarine habitats and substrates for juvenile, subadult, and adult life stages.

2) Water flow. Within bays and estuaries adjacent to the Sacramento River (i.e., the Sacramento-San Joaquin Delta and the Suisun, San Pablo, and San Francisco bays), sufficient flow into the bay and estuary to allow adults to successfully orient to the incoming flow and migrate upstream to spawning grounds.

3) Water quality. Water quality, including temperature, salinity, oxygen content, and other chemical characteristics necessary for normal behavior, growth, and viability of all life stages.

4) Migratory corridor. A migratory pathway necessary for the safe and timely passage of all life stages within estuarine habitats and between estuarine and riverine or marine habitats.

5) Depth. A diversity of depths necessary for shelter, foraging, and migration of juvenile, subadult, and adult life stages.

6) Sediment quality. Sediment quality (i.e., chemical characteristics) necessary for normal behavior, growth, and viability of all life stages.

Physical and biological features for sDPS green sturgeon in the lower reaches of the Sacramento River and the Delta have been significantly altered from their historical condition. Green sturgeon exhibit very different life history characteristics from those of salmonids and therefore utilize habitat within the proposed action area differently; sDPS green sturgeon are thought to exhibit rearing behavior in the lower reaches of the Sacramento River and the Delta as juveniles and subadults prior to migrating to the ocean, though little is known about the behavior of these life stages in the Delta (Radtke 1966, National Marine Fisheries Service 2015a). Loss of riparian habitat complexity in the Sacramento River and Delta has likely posed less of a threat to sDPS green sturgeon because these life stages are benthically oriented. However, it is likely that reverse flows generated by Delta water exports affect the sDPS green sturgeon juvenile and subadult life stages to some degree as evidenced by juvenile captures at CVP and SWP salvage facilities during high water years (California Department of Fish and Wildlife 2018).

Currently, many of the PBFs of sDPS green sturgeon are degraded and provide limited high quality habitat. Factors that lessen the quality of migratory corridors for juveniles include unscreened or inadequately screened diversions, altered flows in the Delta, and presence of contaminants in sediment. Although the current conditions of sDPS green sturgeon critical habitat are significantly degraded, the spawning habitat, migratory corridors, and rearing habitat that remain in both the Sacramento River watershed, the Delta, and nearshore coastal areas are considered to have high intrinsic value for the conservation of the species.

4.9. Southern Resident Killer Whale Distinct Population Segment

The SRKW DPS, composed of J, K, and L pods, was listed as endangered under the ESA on November 18, 2005 (70 FR 69903). A 5-year review under the ESA completed in 2021 concluded that SRKWs should remain listed as endangered and includes recent information on the population, threats, and new research results and publications (National Marine Fisheries Service 2021j). NMFS considers SRKWs to be currently among nine species at high risk of extinction as part of NMFS' Species in the Spotlight initiative[8] because of their endangered status, their declining population trend, and because they are considered high priority for recovery due to conflict with human activities and based on current recovery programs addressing those threats. The population has relatively high mortality and low reproduction, unlike other resident killer whale populations, which have generally been increasing since the

[8] https://www.fisheries.noaa.gov/feature-story/recovering-threatened-and-endangered-species-report-congress-2019-2020

1970s (Carretta et al. 2023). Current management priorities are outlined in the 2021-2025 Species in the Spotlight Action Plan.[9]

The factors limiting SRKW recovery as described in the final recovery plan include reduced prey availability and quality, high levels of contaminants from pollution, and disturbances from vessels and sound (National Marine Fisheries Service 2008d). This section summarizes the status of SRKW throughout their range and information taken largely from the recovery plan (National Marine Fisheries Service 2008d) the most recent 5-year review (National Marine Fisheries Service 2021j), the Pacific Fishery Management Council (PFMC) SRKW Ad Hoc Workgroup's report (Pacific Fishery Management Council 2020), as well as new data that became available more recently.

4.9.1. Abundance, Productivity, and Trends

Killer whales, including SRKWs, are a long-lived species, and sexual maturity can occur at age 10 (National Marine Fisheries Service 2008d). Females produce a low number of surviving calves ($n < 10$, but generally fewer) over the course of their reproductive lifespan (Bain 1990, Olesiuk et al. 1990). Compared to Northern Resident killer whales (NRKWs), which are a resident killer whale population with a sympatric geographic distribution ranging from the coastal waters of Washington State and British Columbia to Southeast Alaska, SRKW females appear to have reduced fecundity (Ward et al. 2013, Vélez-Espino et al. 2014), and all age classes of SRKWs have reduced survival compared to other fish-eating populations of killer whales in the Northeast Pacific (Ward et al. 2013).

Since the early 1970s, annual summer censuses have occurred in the Salish Sea using photo-identification techniques (Bigg et al. 1990, Center for Whale Research 2023). The population of SRKW was at its lowest known abundance ($n = 67$) in the early 1970s following live-captures for aquaria display and highest recorded abundance (98 animals) in 1995. Subsequently, the population declined from 1995-2001 (from 98 whales in 1995 to 81 whales in 2001). Although the population experienced growth between 2001 and 2006 and a brief increase from 78 to 81 whales as a result of multiple successful pregnancies ($n = 9$) in 2013 and 2014, the population has been declining since 2006. At the time of the 2023 summer census, the CWR reported 75 SRKWs in the population, including two calves that were born in 2023 (Figure 15, Center for Whale Research 2023) Since the 2023 census, one adult male is presumed dead, bringing the population size to 74. The previously published historical estimated abundance of SRKWs was 140 animals (National Marine Fisheries Service 2008d), which included the number of whales killed or removed for public display in the 1960s and 1970s (summed across all years) added to the remaining population at the time the captures ended.

[9] https://www.fisheries.noaa.gov/resource/document/species-spotlight-priority-actions-2021-2025-southern-resident-killer-whale

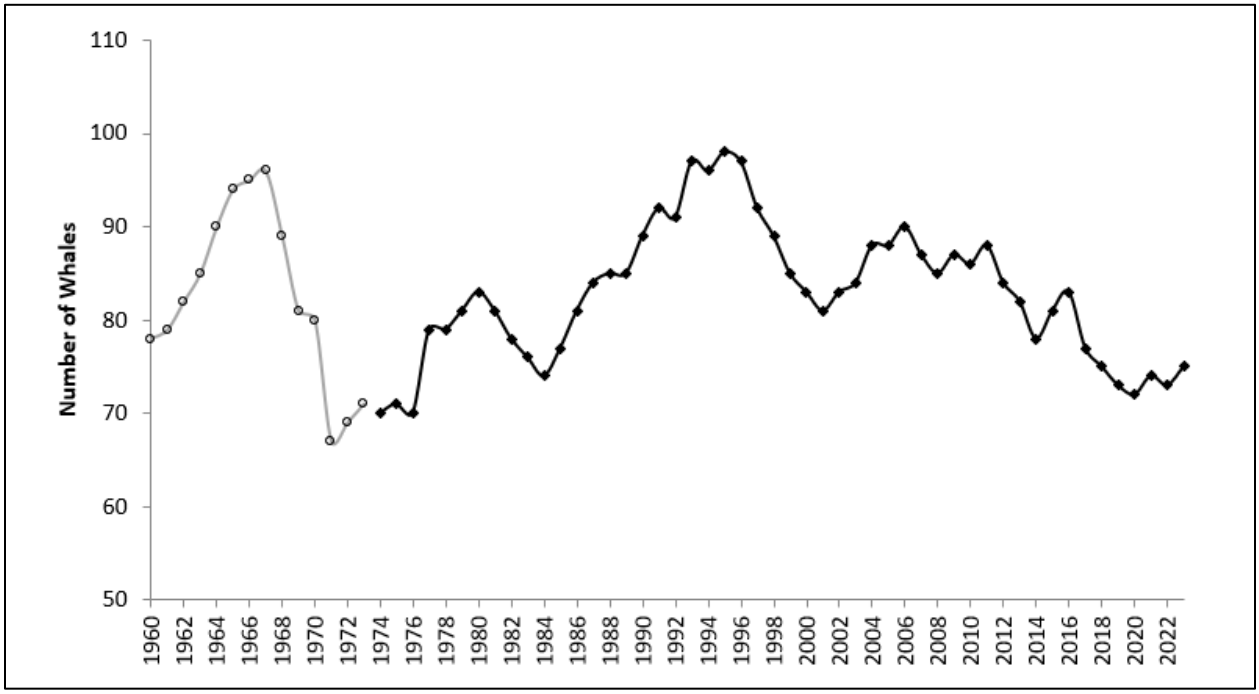


Figure 15. Population size and trend of Southern Resident killer whales, 1960–2023.

Data from 1960 to 1973 (open circles, gray line) are number projections from the matrix model of (Olesiuk et al. 1990). Data from 1974 to 2023 (diamonds, black line) were obtained through photo-identification surveys of the three pods (J, K, and L) and were provided by the Center for Whale Research (unpublished data) and (National Marine Fisheries Service 2008d). Data for these years represent the number of whales present at the end of each calendar year, or after the summer census for 2012 onwards.

Seasonal mortality rates among SRKWs and NRKWs may be highest during the winter and early spring, based on strandings data and the number of animals missing from pods returning to inland waters each spring. (Olesiuk et al. 2005) reported that high neonate mortality occurred outside of the summer season. Additionally, multiple new calves have been documented in winter months that did not survive to the following summer season (CWR unpublished data). Stranding rates are higher in winter and spring for all killer whale forms in Washington and Oregon (Norman et al. 2004) and a recent review of killer whale strandings in the Northeast Pacific provided insight into health, nutritional status and causes of mortality for all killer whale ecotypes (Raverty et al. 2020).

The Northwest Fisheries Science Center (NWFSC) continues to evaluate changes in fecundity and survival rates and has updated population viability analyses conducted for the 2004 Status Review of Southern Resident Killer Whales (Krahn et al. 2004), the science panel review (Hilborn et al. 2012, Ward et al. 2013), and previous 5-year status reviews (National Marine Fisheries Service 2011b, National Marine Fisheries Service 2016f). Subsequently, population estimates, including data from the most recent five years (2017–2021), project a downward trend over the next 25 years (Figure 16). The declining trend is, in part, due to the changing age and sex structure of the population (the sex ratio at birth was estimated in the model at 55 percent

male and 45 percent female following current trends), but also related to the relatively low fecundity rate observed from 2017 to 2021. Though these fecundity rates are declining, average SRKW survival rates estimated by the NWFSC have been slowly increasing since the late 1990s. The population projection indicates the strongest decline if future fecundity rates are assumed to be similar to 2017–2021 and a higher, but still declining, population if average fecundity and survival rates over all years (1985–2021) are used (Figure 16). The projection using the highest fecundity and survival rates (1985–1989) shows some stability and even a slight increase over the next decade before severely declining. A 25-year projection was selected because as the model projects out over a longer time frame (e.g., 50 years), there is increased uncertainty around the estimates (Hilborn et al. 2012).

The scenario using the most recent (2017–2021) survival and fecundity rates may be a more reliable estimation if current levels of survival and poor reproduction continue. This predicted downward trend in the model is driven by the current age and sex structure of young animals and a number of older animals in the population. The range of population trajectories reflects the endangered status of the SRKWs and variable periods of decline experienced over the long and short term and is based on a limited data set for the small population. The analysis does not link population growth or decline to any specific threat, but reflects the combined impacts of all past threats. As a long-lived species with a low reproductive rate, it will take time for SRKWs to respond to a reduction in threats. It will be difficult to link specific actions to potential future improvements in the population trajectory. One assumption shared across all scenarios presented here is that female reproduction will be similar to the average (given the age of animals and time period). Because many reproductive-aged females have not produced a calf in the last decade, we would expect the SRKW population to decline even more rapidly if the number of females not reproducing continues to increase or if these females continue to fail to produce calves.

Another factor to consider is the potential effects of inbreeding (generally a risk for any small population). Many of the offspring in recent years were sired by two fathers, meaning that less than 30 individuals make up the effective reproducing portion of the population (Ford et al. 2011, Ford et al. 2018). Additionally, several offspring that were tested for paternity resulted from matings between parents and their own offspring (Ford et al. 2018). While these inbreeding effects are estimated to be slightly negative, they are difficult relationships to estimate given the small sample size. Recent genomic analyses indicate that the SRKW population has greater inbreeding and carries a higher load of deleterious mutations than do Alaska resident or transient killer whales, and that inbreeding depression is likely impacting the survival and growth of the population (Kardos et al. 2023). These factors likely contribute to the SRKW's poor status.

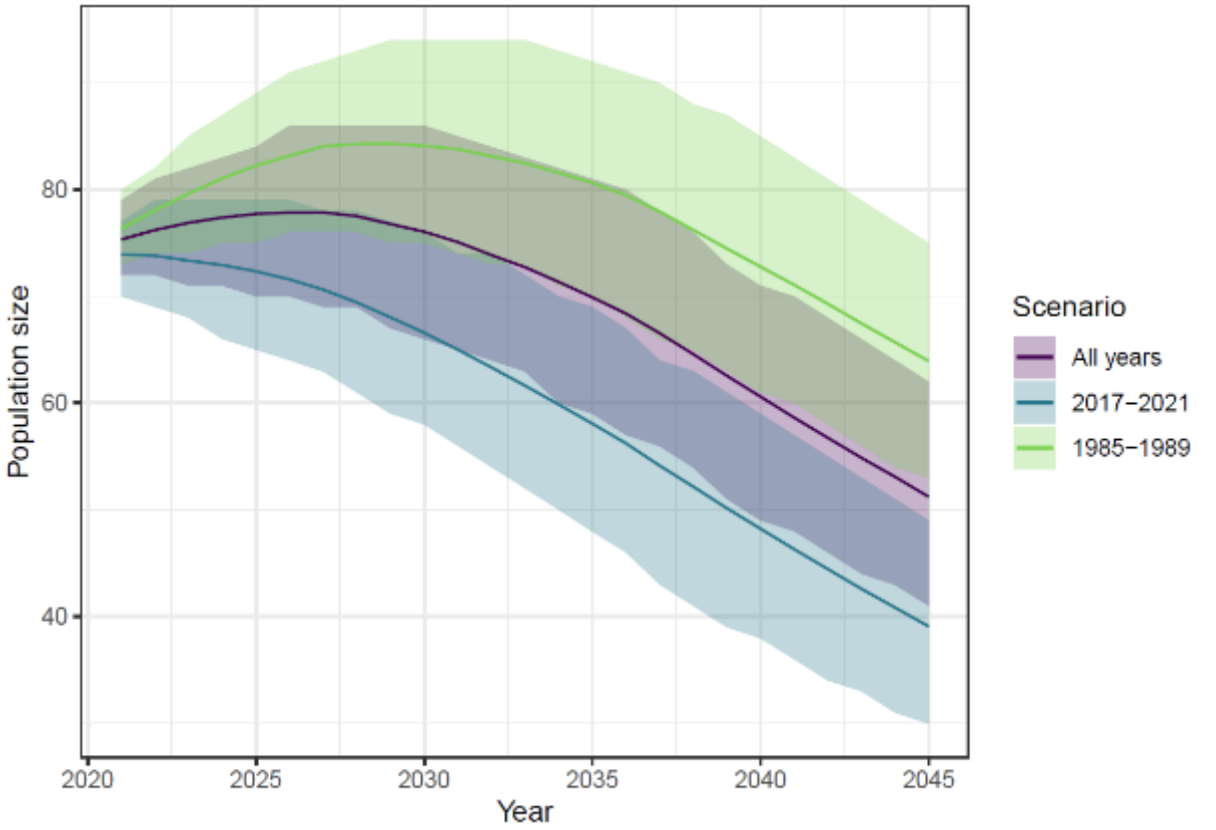


Figure 16. Southern Resident killer whale population size projections from 2020 to 2045 using three scenarios: (1) projections using fecundity and survival rates estimated over the entire time series (1985–2021), (2) projections using rates estimated over the last five years (2017–2021), and (3) projections using the highest survival and fecundity rates estimated, during the period 1985–1989.

Source: (National Marine Fisheries Service 2021j)

Because of this population's small abundance, it is also susceptible to demographic stochasticity, or randomness in the pattern of births and deaths among individuals in a population. Several sources of demographic variance (e.g., differences between or within individuals) can affect small populations and contribute to variance in a population's growth and increased extinction risk. Sources of demographic variance can include environmental stochasticity, or fluctuations in the environment that drive changes in birth and death rates, and demographic heterogeneity, or variation in birth or death rates of individuals because of differences in their individual fitness (including sexual determinations). In combination, these and other sources of random variation combine to amplify the probability of extinction (Gilpin and Michael 1986, Fagan and Holmes 2006, Melbourne and Hastings 2008). The larger the population size, the greater the buffer against stochastic events and genetic risks.

Individual variation in reproductive success can influence broader population growth or decline, especially for smaller, more isolated populations such as the SRKW (Coulson et al. 2006, Hochachka 2006). Additionally, whether a female produces a son or daughter may influence her lifetime reproductive success (Weiss et al. 2023). Similarly, the number of reproducing females in a population can signal potential growth or decline. In the SRKW population, the number of

reproductive aged females was at its lowest point in the late 1970s, in part because of the prior harvesting that occurred into the early 1970s (Figure 17). Though the overall number of reproductive females has fluctuated between 25 to 35 for most of the last 40 years, there have been contrasting changes by pod, with declines in L pod females and increases in J pod (Figure 17, Ward 2021). At the start of the survey in 1976, the distribution of females was skewed toward younger ages with few older, post-reproductive females. In recent years, the distribution is more uniform across female ages (in other words, more females in their 30s). Relatedly, female fecundity at age 20 has declined in recent years, while survival for females and males at age 20 has stayed relatively constant (Ward 2021, Figure 18). This suggests that reduced fecundity may be the driver for the population decline, rather than reduced adult survival. However, given that both high and low fecundity rates have been observed at low total SRKW population sizes (Ward 2021), and that inbreeding depression may be influencing survival (Kardos et al. 2023), there is not a clear relationship between declining fecundity rates and SRKW population size.

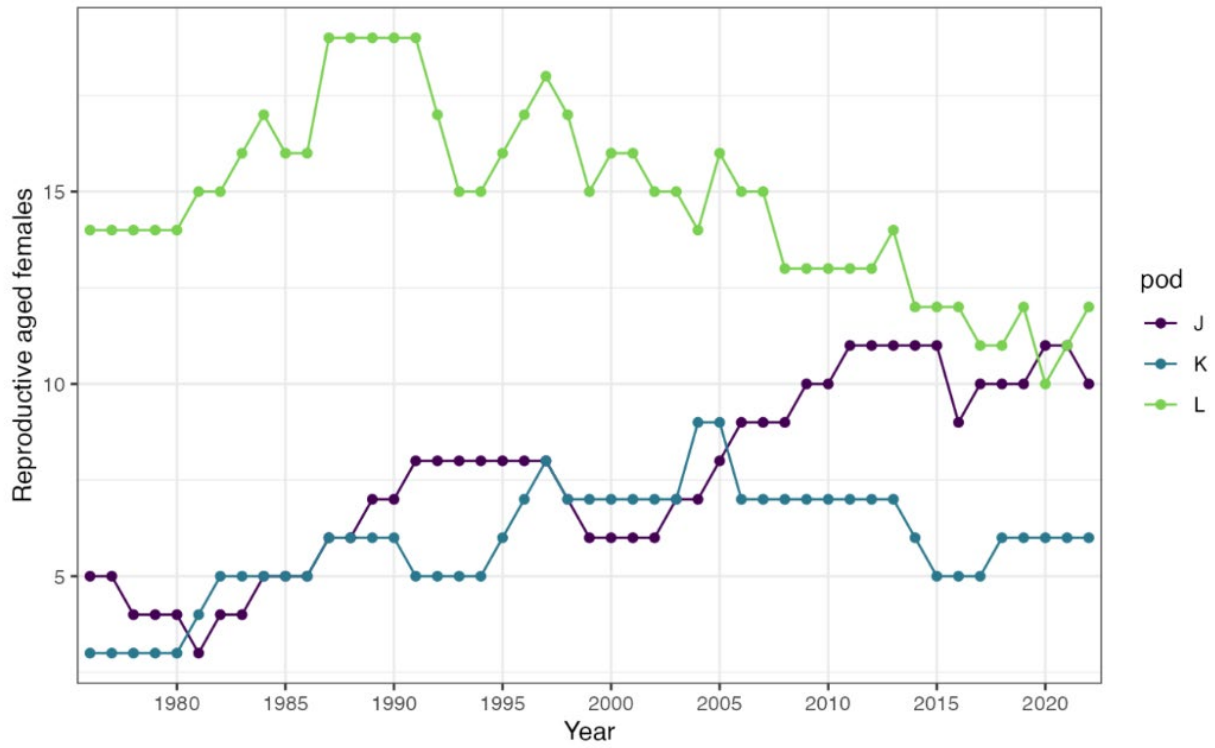


Figure 17. Time series of reproductive age females (10-42, inclusive) for Southern Resident killer whales by year since 1976.

Source: reproduced from (Ward 2021)

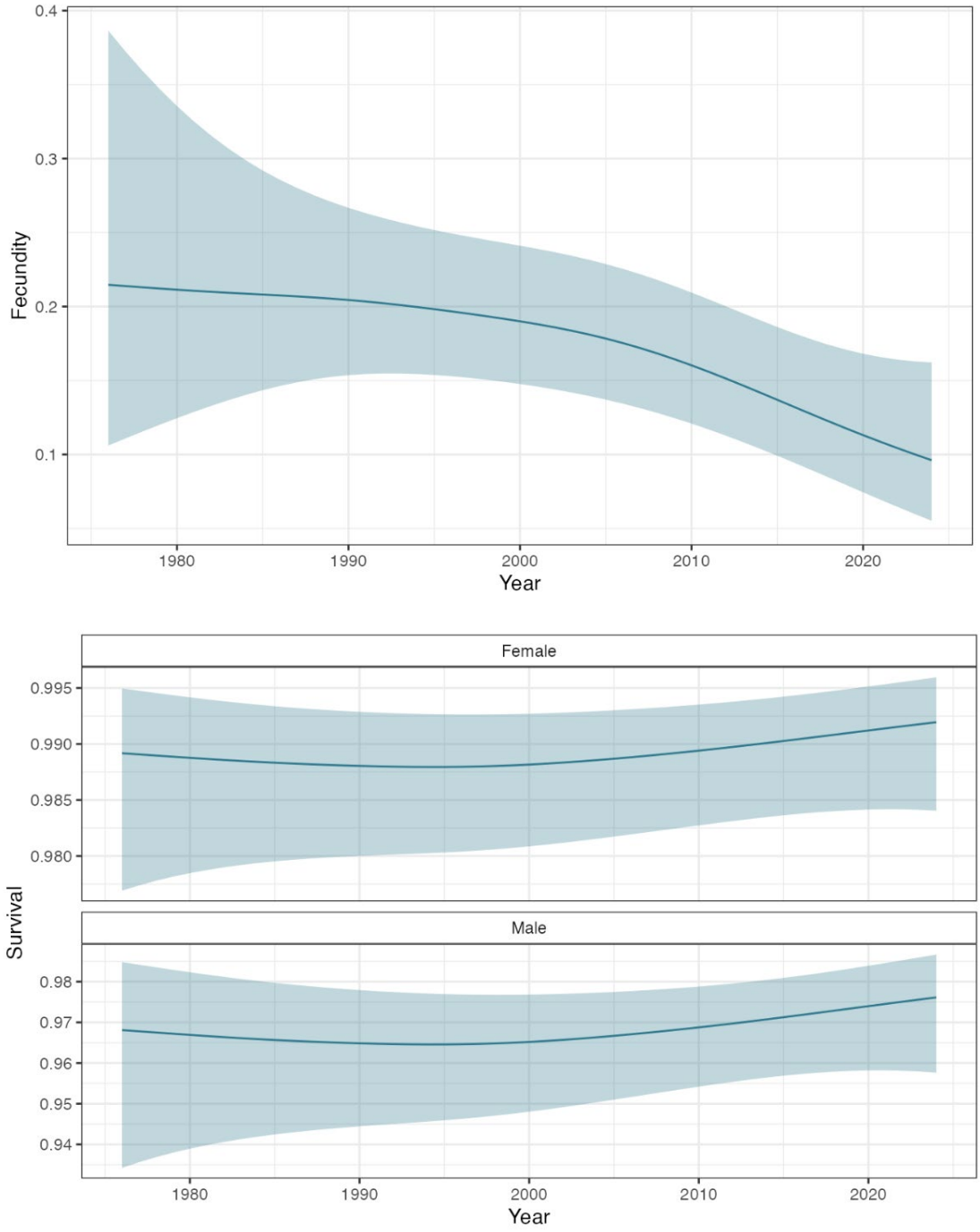


Figure 18. Time series of predicted fecundity rates for a 20-year old Southern Resident killer whale and survival rates for a 20-year old female and male. Estimates are generated from the Bayesian logistic regression models, using priors from the Northern Resident killer whale population. Ribbons represent 95 percent confidence intervals.

Source: reproduced from (Ward 2024)

Previous work using fecal hormone data from SRKWs showed that up to 69 percent of detected pregnancies do not produce a documented calf, and an unprecedented half of those occurred relatively later in the pregnancy when energetic costs and physiological risk to the mother are higher (Wasser et al. 2017). Recent aerial imagery corroborates this high rate of loss (Fearnbach and Durban 2021). The congruence between the rate of loss estimates from fecal hormones and aerial photogrammetry suggests the majority of the loss is in the latter half of pregnancy when photogrammetry can detect anomalous shape after several months of gestation (Durban et al. 2016). Although the rates of successful pregnancies in wild killer whale populations is generally unknown, a relatively high level of reproductive failure late in pregnancy is uncommon in mammalian species and suggests there may be cause for concern.

4.9.2. Geographic Range and Distribution

SRKWs occur throughout the coastal waters off Washington, Oregon, and Vancouver Island, Canada and are known to travel as far south as central California and as far north as Southeast Alaska (Figure 19, National Marine Fisheries Service 2008d, Hanson et al. 2013, Carretta 2023), though there has only been one sighting of a SRKW in Southeast Alaska. SRKWs are highly mobile and can travel up to 86 miles (160 kilometers) in a single day (Erickson 1978, Baird 2000), with seasonal movements likely tied to the migration of their primary prey, salmon. During the spring, summer, and fall months, the whales spend a substantial amount of time in the inland waterways of the Strait of Georgia, Strait of Juan de Fuca, and Puget Sound (Bigg 1982, Ford et al. 2000, Krahn et al. 2002, Hauser et al. 2007, Olson et al. 2018, National Marine Fisheries Service 2021j, Ettinger et al. 2022, Thornton et al. 2022). During the fall and early winter, SRKWs, and J pod in particular, expand their routine movements into Puget Sound, likely to take advantage of chum, coho, and Chinook salmon runs (Osborne 1999). Although seasonal movements are somewhat predictable, there can be large inter-annual variability in arrival time and days present in inland waters from spring through fall (Figure 20, Olson et al. 2018, National Marine Fisheries Service 2021j) , with late arrivals and fewer days present in recent years (National Marine Fisheries Service 2021j, Ettinger et al. 2022; though see J pod occurrence in 2022 in Shields [2023]). A recent paper showed a shift in SRKW peak occurrence in the central Salish Sea of 1-5 days later per year (depending on pod, time period, or location) between 1994 and 2017, and the SRKW timing shift is consistent with shifts in peak and first likely occurrence of Fraser River Chinook salmon (Ettinger et al. 2022). Similarly, a recent paper by Stewart et al. (2023) showed a decline in visitation to core inland summer habitat (north Puget Sound) for all pods from 2004 to 2020 and that the occurrence of SRKW may be related to annual Fraser Chinook salmon returns.

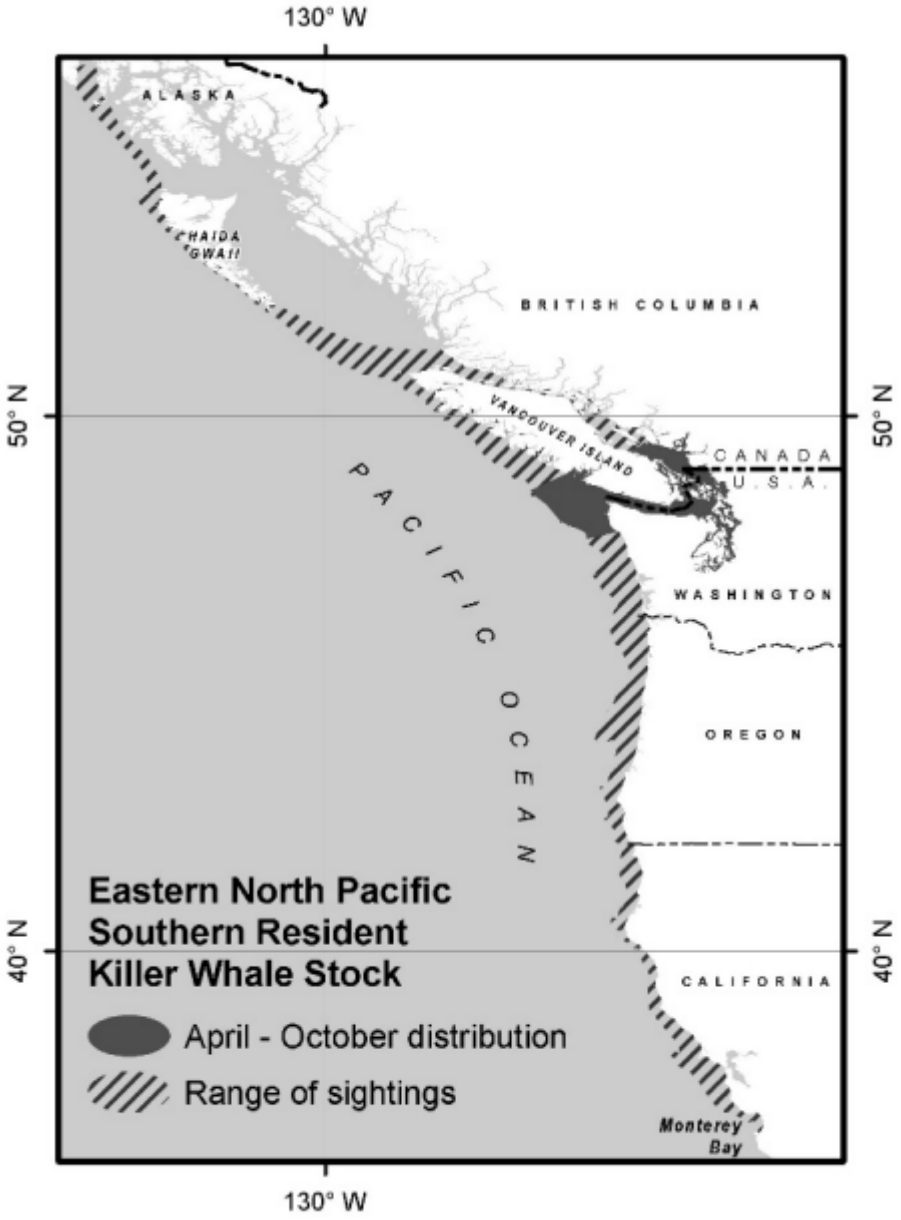
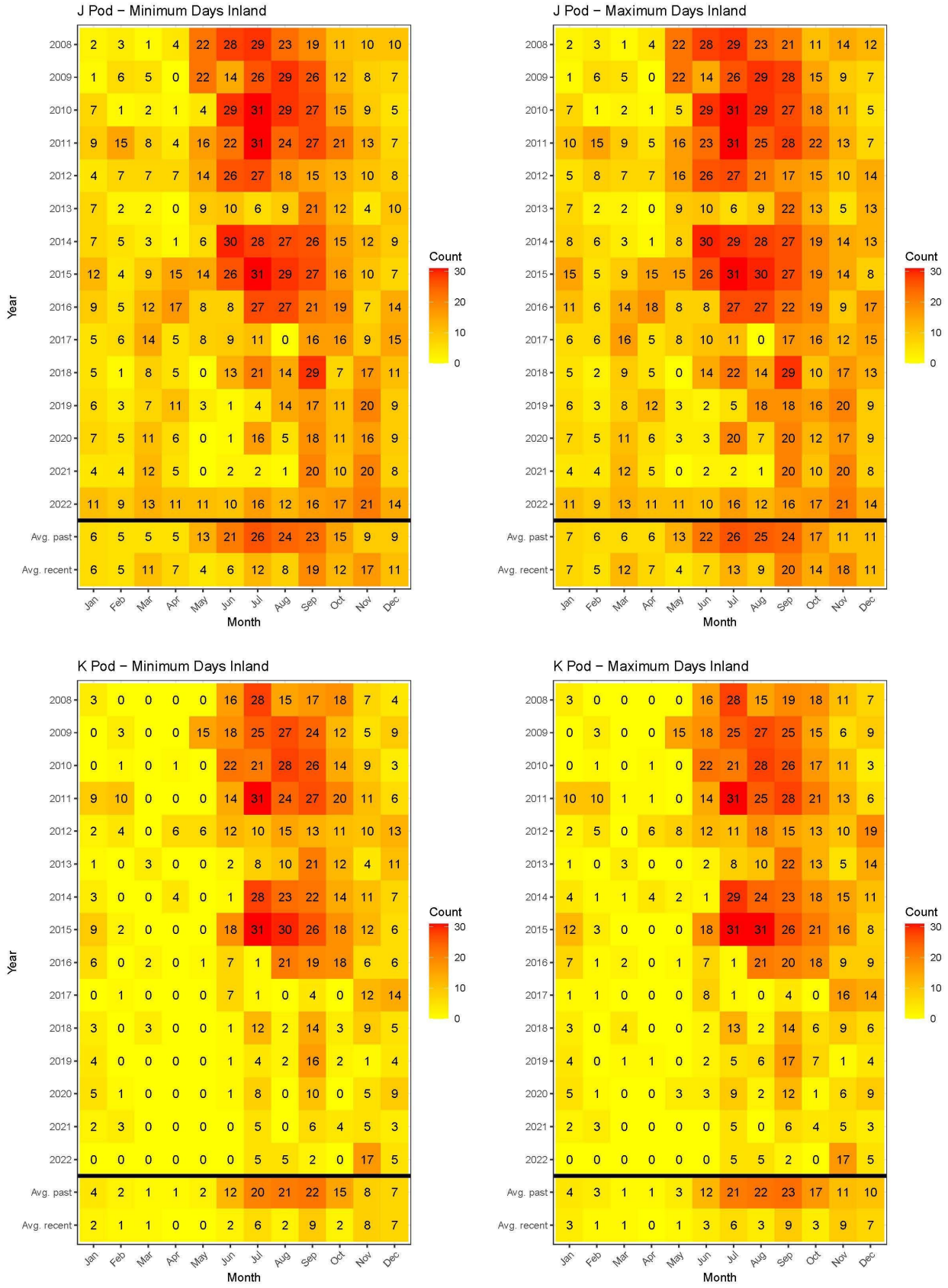


Figure 19. Geographic range of Southern Resident killer whales.

Source: (Carretta 2023)


J Pod – Minimum Days Inland
J Pod – Maximum Days Inland
K Pod – Minimum Days Inland
K Pod – Maximum Days Inland
Year
Month
Count
30
20
10
0
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
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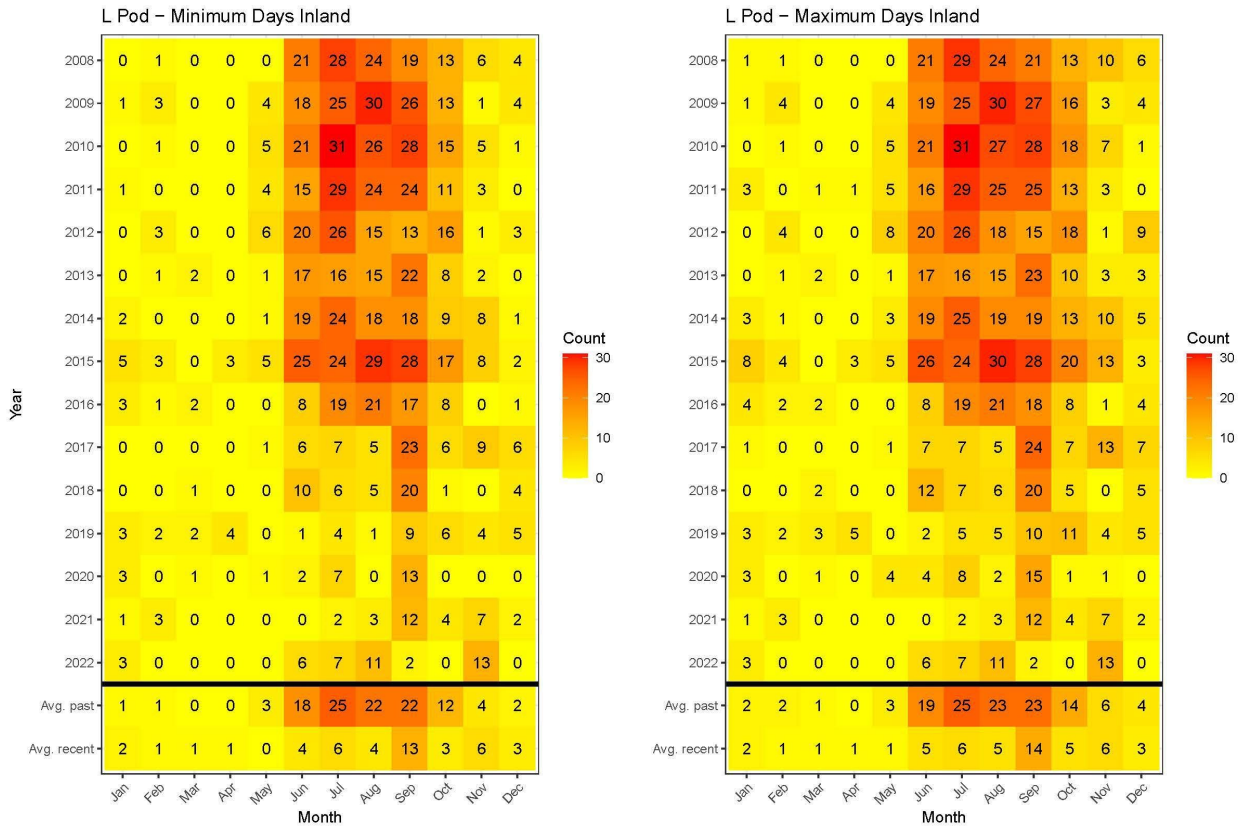


Figure 20. Minimum and maximum number of days that each Southern Resident killer whale (SRKW) pod (J, K, or L) was present in inland waters of the Salish Sea by year and month based on opportunistic sightings.

Source:(National Marine Fisheries Service 2021j) Whale Museum, unpublished data). "Avg past" is the average before 2017 (2008–2016) and "Avg recent" is the average from 2017 to 2022. Data are available prior to 2008 but we used the past 15 years to represent more recent history. Minimum Days Inland includes only sightings where pod was specified and known with certainty. Maximum Days Inland include sightings where pod was specified, including when there was uncertainty, and also includes counts of sightings of SRKWs (without pod specified) if no specific pod was listed as sighted any time that day. The area of the Salish Sea included in this figure encompasses waters of both the United States and Canada, using the quadrant area defined by The Whale Museum (Olson et al. 2018) and extending further west into the Strait of Juan de Fuca to the edge of inland SRKW critical habitat at the Cape Flattery-Tattoosh-Bonilla Point line.

Land- and vessel-based opportunistic and survey-based visual sightings, satellite tracking, and passive acoustic research have provided an updated estimate of the whales' coastal range. Since 1975, confirmed and unconfirmed opportunistic SRKW sightings from the general public or researchers have been collected off British Columbia, Washington, Oregon, and California. Because of the limitations of not having controlled and dedicated sampling efforts, these confirmed opportunistic sightings have provided only general information on the whales' potential geographic range during this period of time (i.e., there are no data to describe the whales' general geographic range prior to 1975). Together, these SRKW sightings have confirmed their presence as far north as Chatham Strait, Southeast Alaska and as far south as Monterey Bay, California (National Marine Fisheries Service 2021h). Fisheries and Oceans

Canada models of SRKW occurrence based on sightings data show hot spots of occurrence off the west side of Vancouver Island at Swiftsure Bank, the west side of San Juan Island, and near the mouth of the Fraser River (Thornton et al. 2022). Additionally, the Pacheedaht First Nation has conducted surveys for SRKW occurrence in the Strait and Swiftsure areas from 2020 to 2022.

As part of a collaborative effort between the NWFSC, Cascadia Research Collective, and the University of Alaska, satellite-linked tags were deployed on eight male SRKWs (three tags on J pod members, two on K pod, and three on L pod) from 2012 to 2016 in Puget Sound or in the coastal waters of Washington and Oregon. The tags were monitored for a range of signal contact durations from 3 days to 96 days depending on the tag, with deployment from late December to mid-May. Approximately 95 percent of the SRKW locations were within 34 kilometers of the shore and 50 percent of these were within 10 kilometers of the coast (Hanson et al. 2017). Only 5 percent of locations were greater than 34 kilometers (21.1 miles) from the coast, but no locations exceeded 75 kilometers (46.6 miles). Almost all (96.5 percent) outer coastal locations of satellite-tagged SRKWs occurred in continental shelf waters of 200 meters (656.2 feet) depth or less, 77.7 percent were in waters less than 100 meters (328.1 feet) depth, and only 5.3 percent were in waters less than 18 meters (59 feet, Table 15). The tags transmitted multiple locations per day to assess winter movements and occurrences of SRKW (Hanson et al. 2017).

Table 15. Satellite-linked tags deployed on Southern Resident killer whales 2012–2016.

Whale ID	Pod association	Date of tagging	Duration of signal contact (days)
J26	J	20-Feb-12	3
L87	J	26-Dec-13	31
J27	J	28-Dec-14	49
K25	K	29-Dec-12	96
L88	L	8-Mar-13	8
L84	L	17-Feb-15	93
K33	K	31-Dec-15	48
L95	L	23-Feb-16	3

Source:(Hanson et al. 2018). This study was part of a collaborative effort between the Northwest Fisheries Science Center, Cascadia Research Collective, and the University of Alaska.

The winter locations of the tagged whales included inland and coastal waters. The inland waters range occurs across the entire Salish Sea, from the northern end of the Strait of Georgia and Puget Sound, and coastal waters from the central west coast of Vancouver Island, British Columbia to northern California (Hanson et al. 2017). The tagging data from 2012 to 2016 provided general information on the home range and overlap of each pod and areas that are used more frequently than others by each pod. Specifically, J pod had high use areas or hot spots (defined as 1 to 3 standard deviations based on a duration of occurrence model of the tagging

data) in the northern Strait of Georgia and the west entrance to the Strait of Juan de Fuca where they spent approximately 30 percent of their time, but they spent relatively little time in other coastal areas (Figure 21). On the other hand, K and L pods occurred almost exclusively on the continental shelf during December to mid-May, primarily on the Washington coast, with a hot spot area between Grays Harbor and the Columbia River and off Westport, spending approximately 53 percent of their time there (Figure 22, Hanson et al. 2017, Hanson et al. 2018). These differences resulted in generally minimal overlap between J pod and both K and L pods. There is overlap in high use areas near the Strait of Juan de Fuca western entrance for a total area of approximately 200 square kilometers (77 square miles), which comprised only 0.5 percent of the three pods' ranges (Figure 21 and Figure 22).

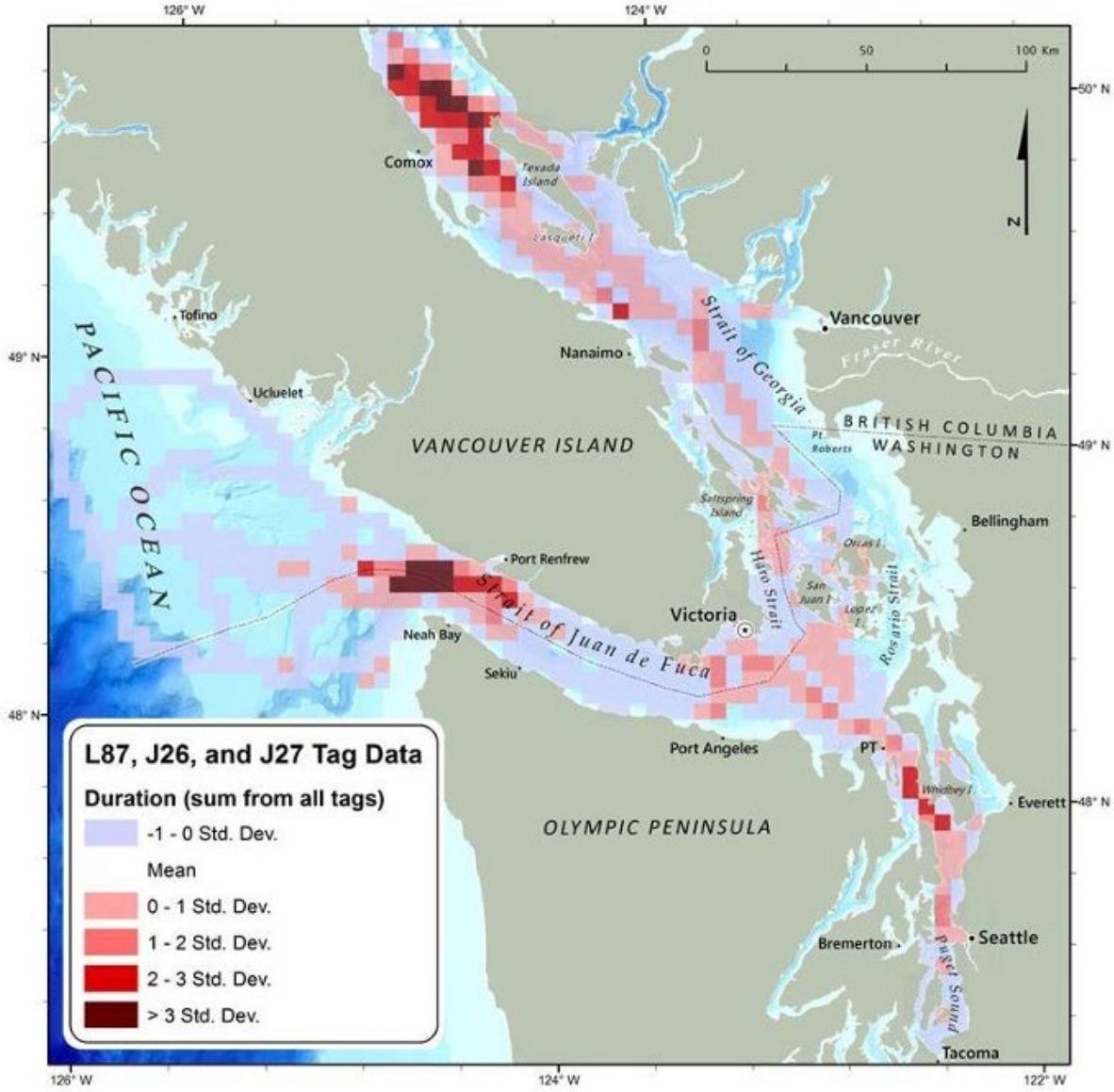


Figure 21. Duration of occurrence model output for J pod tag deployments. "High use areas" or hot spots are illustrated by the 0 to >3 standard deviation pixels.

Source: (Hanson et al. 2017)

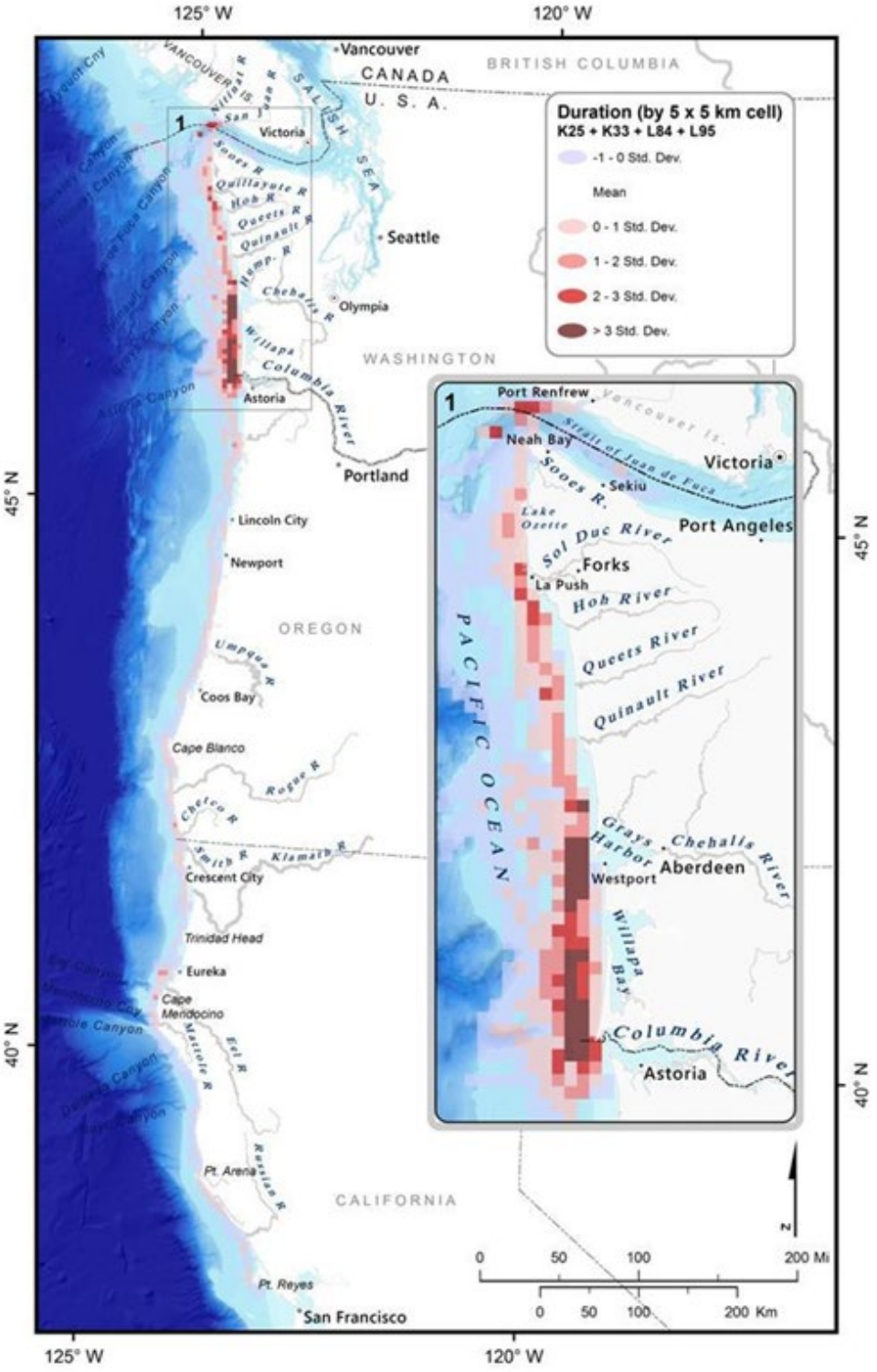


Figure 22. Duration of occurrence model for all unique K and L pod tag deployments. "High use areas" or hot spots are illustrated by the 0 to > 3 standard deviation pixels.

Source: (Hanson et al. 2017)

Passive acoustic recorders were deployed off the coasts of California, Oregon, and Washington in most years since 2006 to assess SRKW seasonal uses of these areas via the recording of stereotypic calls of the SRKWs (Hanson et al. 2013, Emmons et al. 2019). Two types of passive acoustic recorders have been deployed; passive aquatic listeners were deployed from 2006 to 2008, and ecological acoustic recorders have been deployed since 2008, with up to seven deployed from 2008 to 2011 (depending on year) and additional deployments beginning in 2014, including 17 sites off the Washington coast in the fall of 2014 (Figure 23 and Figure 24). From 2006 to 2011, passive aquatic listeners and ecological acoustic recorders were deployed in areas thought to be used frequently by SRKWs based on previous sightings (Figure 23, Hanson et al. 2013). The number of recorder sites off the Washington coast increased from 7 to 17 in the fall of 2014 and locations (Figure 24) were selected based on "high use areas" or hot spots identified in the duration of an occurrence model developed from the SRKW tagging information from Hanson et al. (2017) and sites within the United States Navy's Northwest Training Range Complex in order to determine if SRKWs used these areas in seasons other than winter when satellite-linked tags were not deployed (Hanson et al. 2017, Emmons et al. 2019). Three primary hot spots identified through the winter satellite tagging data were used to place multiple additional recorders, specifically (1) the Washington coast, particularly between Grays Harbor and the mouth of the Columbia River (primarily for K and L pods); (2) the west entrance to the Strait of Juan de Fuca (primarily for J pod); and (3) the northern Strait of Georgia (primarily for J pod). It is important to note that recorders deployed within the Navy's Northwest Training Range Complex were designed to assess spatial use off the Washington coast and thus the effort was higher in this area (i.e., the number of recorders increased in this area) compared to off the coasts of Oregon and California.

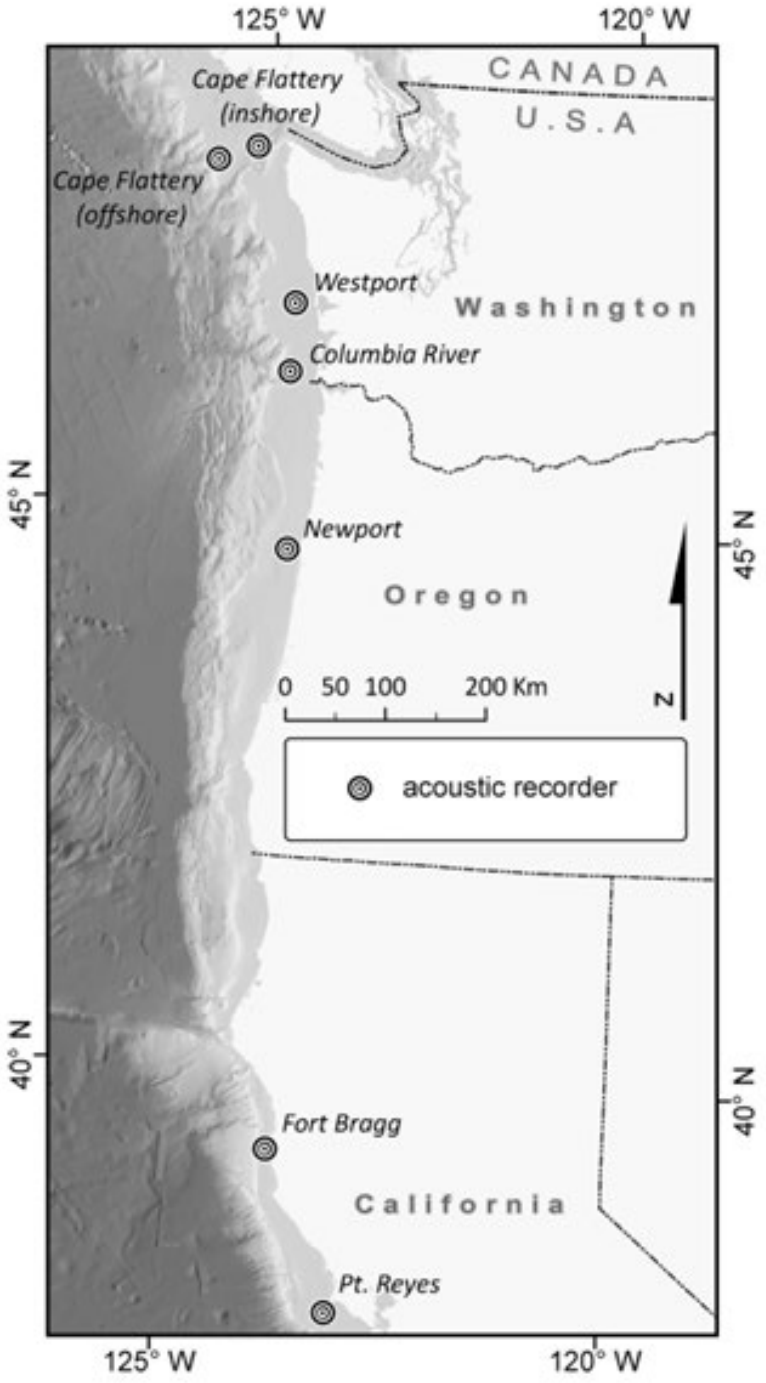


Figure 23. Deployment locations of acoustic recorders on the West Coast of the United States from 2006 to 2011.

Source: (Hanson et al. 2013)

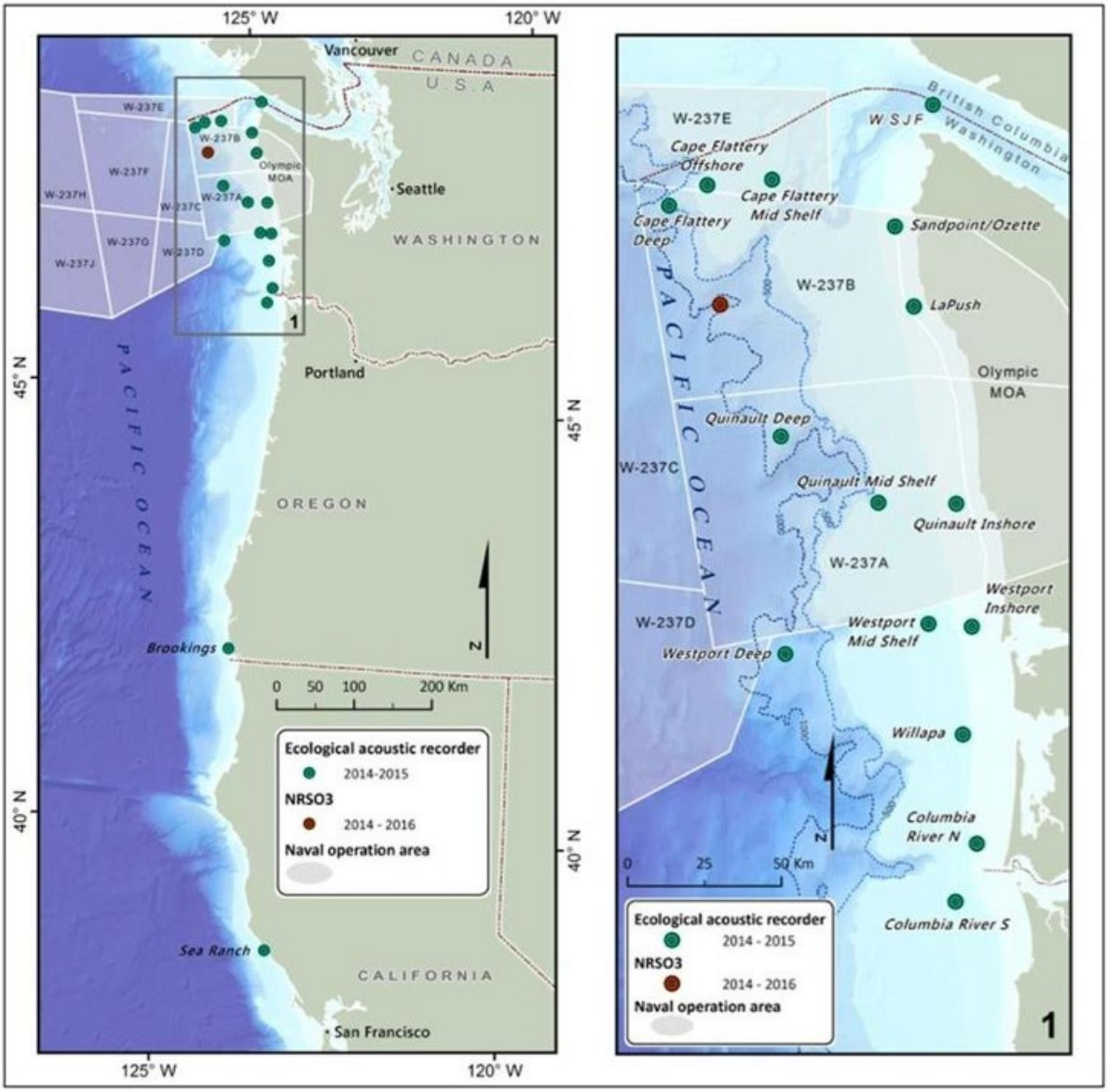


Figure 24. Locations of passive acoustic recorders deployed beginning in the fall of 2014.

Source: (Hanson et al. 2017)

There were acoustic detections off of the Washington coast in all months of the year (Figure 25), with greater than 2.4 detections per month from January through June and a peak of 4.7 detections per month in both March and April, indicating that the SRKW may be present in Washington coastal waters at nearly any time of year, which is more often than previously believed (Hanson et al. 2017, Emmons et al. 2021). Acoustic recorders were deployed off Newport, Fort Bragg, and Port Reyes from 2008 to 2013, and SRKW were detected 28 times (Emmons et al. 2019). Between 2014 and 2017, all three SRKW pods were detected in Northern acoustic recorder sites (sites in Figure 24), but only K and L pods were detected in more

Southern sites (Emmons et al. 2021). Also, SRKW were more frequently detected at inshore sites as compared to mid-shelf and offshore sites.

From August 2009 to July 2011, researchers collected data using an autonomous acoustic recorder deployed at Swiftsure Bank to assess how this area is used by NRKW and SRKW as shown in Figure 26 (Riera et al. 2019). SRKWs were detected on 163 days with 175 encounters (see Figure 27 for number of days of acoustic detections by month). All three pods were detected at least once per month except for J pod in January and November and L pod in March. K and L pods were heard more often (87 percent of calls and 89 percent of calls, respectively), between May and September. J pod was heard most often during winter and spring (76 percent of calls during December and February through May, (Riera et al. 2019). K pod had the longest encounters in June, with 87 percent of encounters longer than 2 hours occurring between June and September. L pod had the longest encounters in May, with 79 percent of encounters longer than 2 hours occurring during the summer (May through September). The longest J pod encounters were during winter, with 72 percent of encounters longer than 2 hours occurring between December and May (Riera et al. 2019).

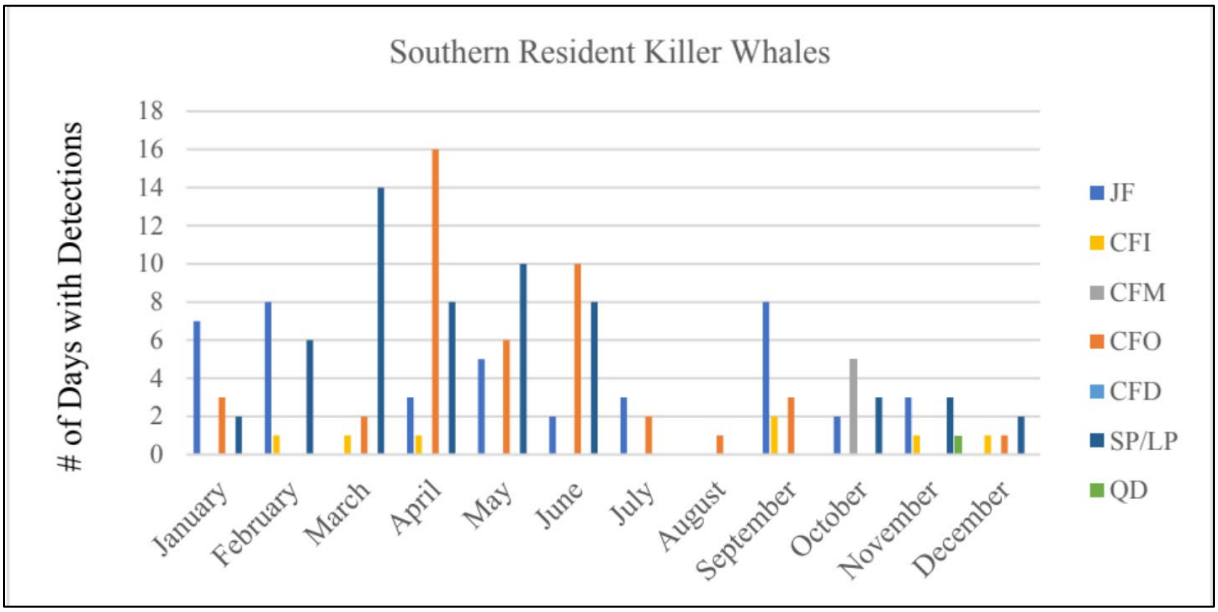


Figure 25. Counts of detections at each northern recorder site by month from 2014 to 2017.

Areas include Juan de Fuca (JF); Cape Flattery Inshore (CFI); Cape Flattery Mid Shelf (CFM); Cape Flattery Offshelf (CFO); Cape Flattery Deep (CFD); Sand Point and La Push (SP/LP); and Quinault Deep (QD).

Source: (Emmons et al. 2019)

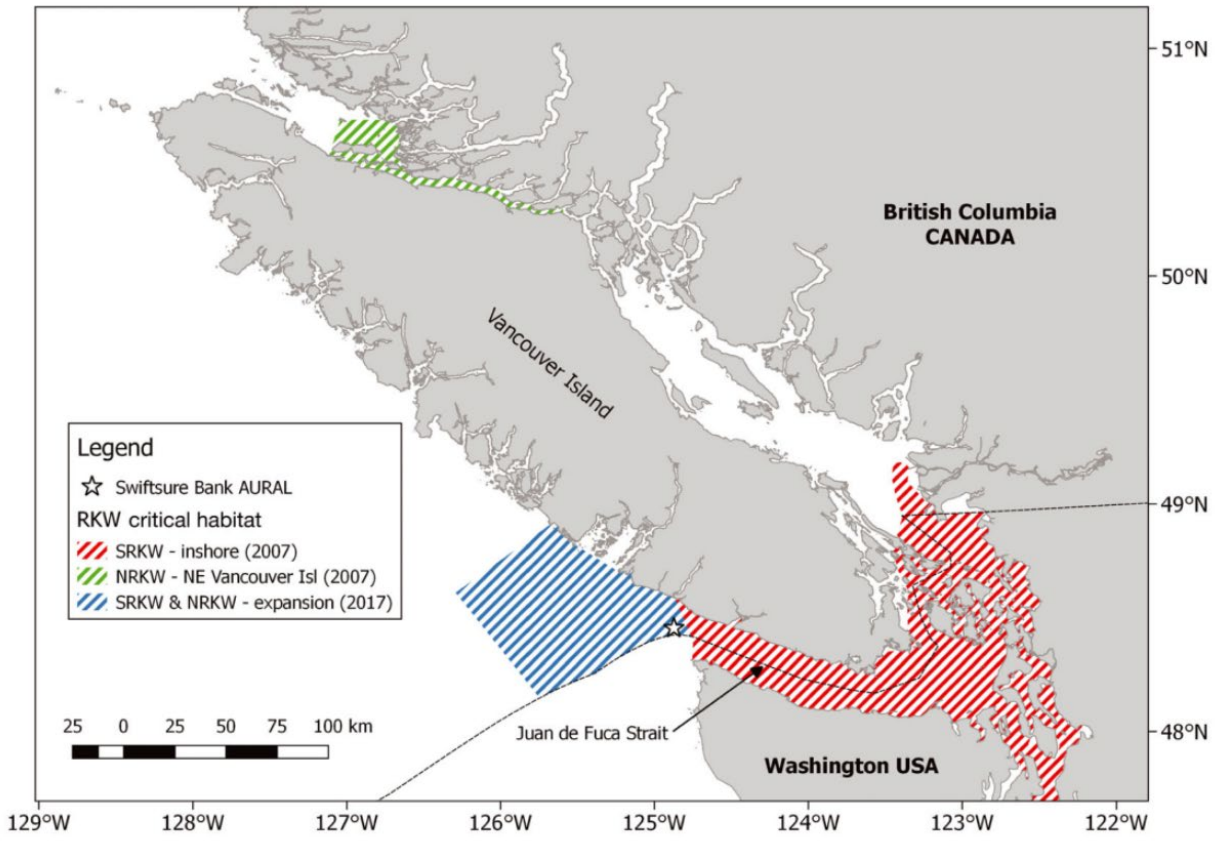


Figure 26. Swiftsure Bank study site off the coast of British Columbia, Canada in relation to the 2007 Northern Resident critical habitat (Northeast Vancouver Island), 2007 Southern Resident killer whale critical habitat (inshore waters) and the 2017 Northern Resident and Southern Resident expansion of critical habitat.

Source: (Riera et al. 2019)

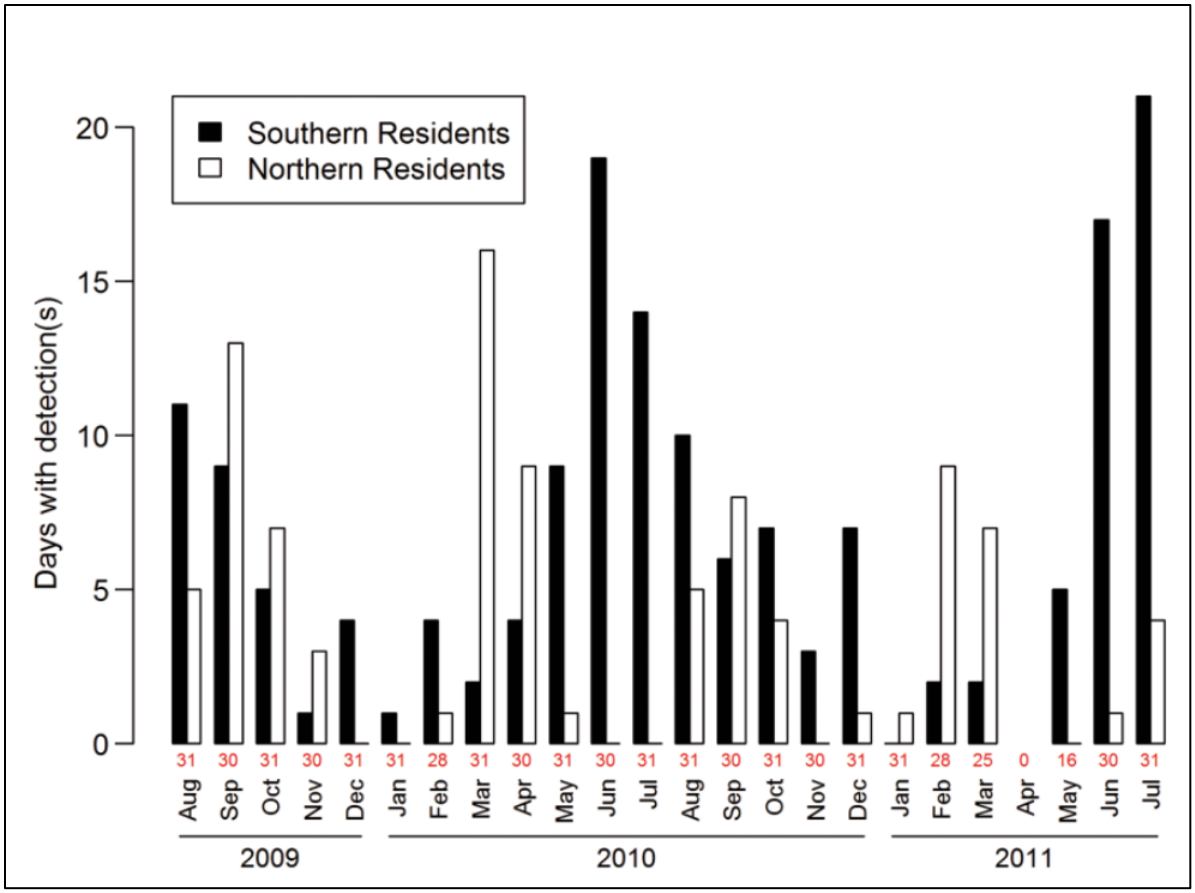


Figure 27. Number of days with acoustic detections of Southern Resident killer whales at Swiftsure Bank from August 2009 to July 2011. Red numbers indicate days of effort.

Source:(Riera et al. 2019)

4.9.3. Limiting Factors and Threats

Several factors identified in the final recovery plan for SRKWs may be limiting recovery. The recovery plan identifies three major threats including (1) quantity and quality of prey, (2) toxic chemicals that accumulate in top predators, and (3) impacts from sound and vessels. Oil spills, disease, and the small population size are also risk factors. It is likely that multiple threats are acting together to impact the whales. Modeling exercises have attempted to identify which threats are most significant to survival and recovery (e.g., Lacy et al. [2017] and Murray et al. [2021]) and available data suggests that all of the threats are potential limiting factors (National Marine Fisheries Service 2008d, Murray et al. 2021, National Marine Fisheries Service 2021j).

Recent work by (Williams et al. 2024) supports these assertions. An updated population viability assessment model drawing from work in Lacy et al. (2017) and Williams et al. (2024) showed that several factors are affecting the SRKW population growth rate, such as Chinook salmon abundance, PCB accumulation, noise from vessels, and inbreeding, among others. While this work indicates that Chinook salmon abundance may have the largest influence on population growth rate, it is unclear how inbreeding depression (Kardos et al. 2023) may temper this response found by the authors. There is unquantified uncertainty in the model and many

limitations to interpreting the specific results, but, in general, the findings by Williams et al. (2024) support the large body of knowledge (see Abundance, Productivity, and Trends, above) projecting population decline over the long term and the importance of Chinook salmon prey abundance, as well as the impact of other limiting factors, on the recovery of SRKWs.

4.9.3.1. Quantity and Quality of Prey

SRKWs consume a variety of fish species (22 species) and one species of squid (Ford et al. 1998, Ford et al. 2000, Ford and Ellis 2006, Hanson et al. 2010b, Ford et al. 2016), but salmon are identified as their primary prey. The best available information suggests an overall preference for Chinook salmon during the summer and fall. Chum salmon (*Oncorhynchus keta*), coho salmon (*O. kisutch*), and steelhead may also be important in the SRKW diet at particular times and in specific locations. Rockfish (*Sebastes* spp.), Pacific halibut (*Hippoglossus stenolepis*), and Pacific herring (*Clupea pallasii*) were also observed during predation events (Ford and Ellis 2006), however, these data may underestimate the extent of feeding on bottom fish (Baird 2000). A number of smaller flatfish, lingcod (*Ophiodon elongatus*), greenling (*Hexagrammos* spp.), and squid have been identified in stomach content analysis of resident killer whales (Ford et al. 1998).

SRKWs are the subject of ongoing research, the majority of which has occurred in inland waters of Washington State and British Columbia, Canada, during summer months and includes direct observation, scale and tissue sampling of prey remains and fecal sampling. The diet data suggest that SRKWs are consuming mostly larger (i.e., generally age 3 and up) Chinook salmon. Chinook salmon is their primary prey despite the much lower abundance in comparison to other salmonids in some areas and during certain time periods. Factors of potential importance include the Chinook salmon's large size, high fat and energy content, and year-round occurrence in the SRKW geographic range. Chinook salmon have the highest value of total energy content compared to other salmonids because of their larger body size and higher energy density (kilocalorie per kilogram, O'Neill et al. 2014). For example, in order for a killer whale to obtain the total energy value of one Chinook salmon, they would need to consume, on average, approximately 2.7 coho, 3.1 chum, 3.1 sockeye, or 6.4 pink salmon (O'Neill et al. 2014). Research suggests that killer whales are capable of detecting, localizing, and recognizing Chinook salmon through their ability to distinguish Chinook salmon echo structure as different from other salmon (Au et al. 2010). Though SRKW do not only consume Chinook salmon, the degree to which killer whales are able to or willing to switch to non-preferred prey sources from their primary prey (i.e., Chinook salmon) in all times and locations is unknown and likely variable depending on time and location.

Recent stable isotope analyses of opportunistically collected scale samples (Warlick et al. 2020) continue to support and validate previous diet studies (Ford et al. 2016) and what is known of SRKW seasonal movements (Olson et al. 2018), but highlight temporal variability in isotopic values. (Warlick et al. 2020) continued to find that Chinook salmon is the primary prey for all pods in summer months, followed by coho and then other salmonids. Carbon signatures in samples varied by month, which could indicate variation in Chinook and coho salmon consumption between months or differences in carbon signatures across salmon runs and life histories. Peaks in carbon signatures in samples varied between J pod and K and L pods. Though Chinook salmon was the primary prey across years, there was inter-annual variability in nitrogen signatures, which could indicate variation in Chinook salmon nitrogen content from year to year,

greater Chinook salmon consumption in certain years versus others, and/or nutritional stress in certain years, but this is difficult to determine.

Over the last forty years, predation on Chinook salmon off the West Coast of North America by marine mammals has been estimated to have more than doubled (Chasco et al. 2017a). In particular, southern Chinook salmon stocks ranging south from the Columbia River have been subject to the largest increases in predation, which Chasco et al. (2017a) suggest may be potentially due to large subsidies of hatchery produced fish. Due to Chinook salmon's northward migratory pathway and assumptions about their ocean residence, Chasco et al. (2017a) suggested that SRKWs may be at a competitive disadvantage to other resident killer whales and marine mammals that also prey on Chinook salmon. In other regions such as the Salish Sea, the combined mammal predation of Chinook salmon likely exceeds removal by harvest after accounting for the growth and survival of juvenile fish consumed (Chasco et al. 2017a, Chasco et al. 2017b). However, for modeled northern Chinook salmon stocks (specifically off Washington, the West Coast Vancouver Island, coastal British Columbia, and Southeast Alaska), predation by marine mammals is near or below fishery harvest (Chasco et al. 2017a), and coastal Washington is an area of high use by SRKWs within their coastal habitat. As recommended by the Orca Task Force Report, evaluation of pinniped predation on salmonids is ongoing (Washington State Academy of Sciences 2022).

4.9.3.1.1. Southern Resident Killer Whale Prey May–September

Prey scale and tissue sampling from May to September in inland waters of Washington and British Columbia indicate that the SRKW diet consists of a high percentage of Chinook salmon (monthly proportions as high as >90 percent; Hanson et al. 2010b, Ford et al. 2016). Genetic analysis of samples from 2006 to 2010 indicate that when SRKWs are in inland waters from May to September, they primarily consume Chinook salmon stocks that originate from the Fraser River (80-90 percent of the diet in the Strait of Juan de Fuca and San Juan Islands; including Upper Fraser, Mid Fraser, Lower Fraser, North Thompson, South Thompson and Lower Thompson), and, to a lesser extent, consume stocks from Puget Sound (North and South Puget Sound), the Central British Columbia Coast, and West and East Vancouver Island (Hanson et al. 2010b). This is not unexpected as all of these stocks are returning to streams proximal to these inland waters during this timeframe. Few diet samples have been collected in summer months outside of the Salish Sea.

DNA quantification methods are also used to estimate the proportion of different prey species in the diet of SRKWs from fecal samples (e.g., Deagle et al. 2005).Ford et al. (2016) confirmed the importance of Chinook salmon to SRKWs in the early- to mid-summer months (May to August) by sequencing DNA from whale feces collected in inland waters of Washington and British Columbia. Salmon and steelhead made up to 98 percent of the inferred diet, of which almost 80 percent were Chinook salmon. Coho salmon and steelhead are also found in the diet in inland waters of Washington and British Columbia during spring and fall months when Chinook salmon are less abundant. Specifically, coho salmon contribute to over 40 percent of the diet in September in inland waters, which is evidence of prey-shifting by SRKWs at the end of summer towards coho salmon (Ford et al. 1998, Ford and Ellis 2006, Hanson et al. 2010b, Ford et al. 2016). Less than 3 percent each of chum salmon, sockeye salmon, and steelhead were observed in fecal DNA samples collected from May to September in inland waters.

4.9.3.1.2. Southern Resident Killer Whale Prey October–December

Prey remains and fecal samples collected in inland waters from October through December indicate Chinook and chum salmon are primary contributors of the whales' diet (Hanson et al. 2021). Diet data for the Strait of Georgia and coastal waters is limited.

4.9.3.1.3. Southern Resident Killer Whale Prey January–April

Collection of prey and fecal samples have also occurred in coastal waters in the winter and spring months, as well as observations of SRKWs overlapping with salmon runs (Wiles 2004, Zamon et al. 2007, Krahn et al. 2009). Although fewer predation events have been observed and fewer fecal samples collected in coastal waters compared to inland waters, recent data indicate that salmon, and Chinook salmon in particular, remains an important dietary component when the SRKWs occur in outer coastal waters during these time frames. Prior to 2013, only three prey samples for SRKWs on the United States' outer coast had been collected (Hanson et al. 2021). From 2013 to 2016, researchers used satellite tags to locate and follow the whales to obtain predation and fecal samples. They collected a total of 57 prey sample items from northern California to northern Washington (Figure 28). The samples indicate that, as is the case in inland waters, Chinook salmon are the primary species detected in diet samples on the outer coast, although steelhead, chum salmon, and Pacific halibut were also detected in the samples. Chum and coho salmon, steelhead, Big skate (*Rana binoculata*), and lingcod were also detected in recent fecal samples (Hanson et al. 2021). These data indicate that the killer whale diet diversifies when Chinook salmon are less abundant (Hilborn et al. 2012, Ford et al. 2016, Hanson et al. 2021). Despite J pod utilizing much of the Salish Sea, including the Strait of Georgia, in winter months (Hanson et al. 2018), few diet samples have been collected in this region in winter.

The occurrence of K and L pods off the Columbia River in March suggests the importance of Columbia River spring runs of Chinook salmon in their diet (Hanson et al. 2013). Chinook salmon genetic stock identification from samples collected in winter and spring in coastal waters from California through Washington included 12 United States West Coast stocks and showed that over half the Chinook salmon consumed originated in the Columbia River (Hanson et al. 2021). Columbia River, Central Valley, Puget Sound, and Fraser River Chinook salmon collectively comprised over 90 percent of 33 Chinook salmon prey samples collected (for which genetic stock origin was determined, of a total 44 prey samples collected) for SRKWs in coastal areas.

As noted, most of the Chinook salmon prey samples opportunistically collected in coastal waters were determined to have originated from the Columbia river basin, including Lower Columbia Spring, Middle Columbia Tule, and Upper Columbia Summer/Fall. In general, we would expect to find these stocks given the diet sample locations (Figure 28). However, the Chinook salmon stocks included fish from as far north as the Taku River (Alaska and British Columbia stocks) and as far south as the Central Valley of California (Hanson et al. 2021).

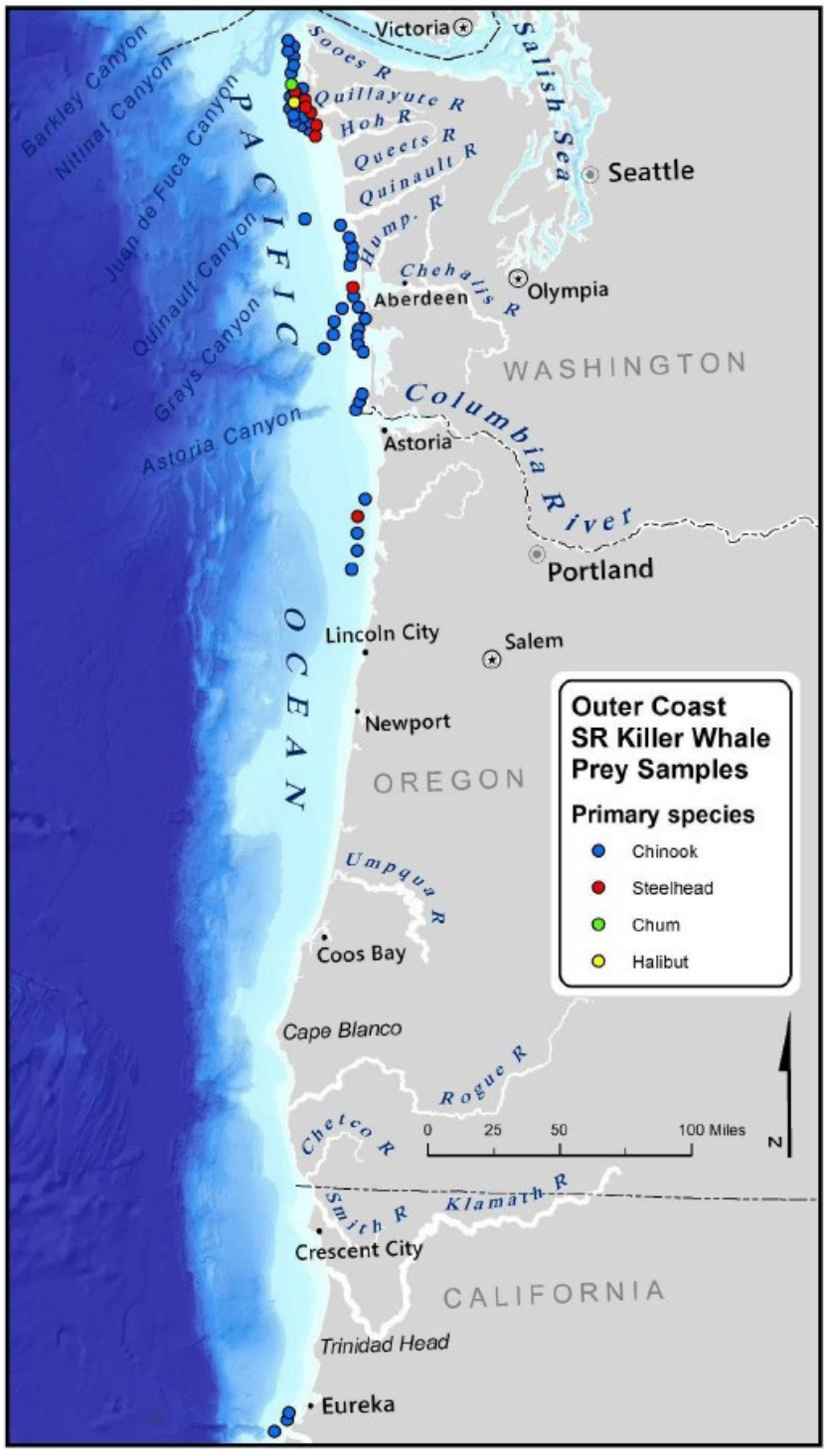


Figure 28. Location and species for scale/tissue samples collected from Southern Resident killer whale predation events in outer coastal waters (stock IDs are considered preliminary).

Source: (National Marine Fisheries Service 2021h)

4.9.3.1.4. Priority Prey Stocks

In an effort to prioritize recovery efforts such as habitat restoration and help inform efforts to use fish hatcheries to increase the SRKW prey base, NMFS and the Washington Department of Fish and Wildlife (WDFW) developed a priority stock report identifying the important Chinook salmon stocks along the West Coast (National Marine Fisheries Service and Washington Department of Fish and Wildlife 2018).[10] The list was created using information on (1) Chinook salmon stocks found in SRKW diet through fecal and prey scale/tissue samples, (2) SRKW body condition over time through aerial photographs, and (3) SRKW spatial and temporal overlap with Chinook salmon stocks ranging from Southeast Alaska to California. Extra weight was given to the salmon runs that support SRKWs during times of the year when the whales' body condition is more likely reduced and when Chinook salmon may be less available (i.e., winter months). This priority stock report will be updated over time as new data become available. The report was designed only to prioritize recovery actions for SRKW; currently, stock-specific abundance estimates have not been factored into the report, therefore it is not intended to assess fisheries actions or prey availability by area. The first 15 salmon stocks on the priority list include fall, spring, and summer Chinook salmon runs in rivers spanning from British Columbia to California, including the Fraser, Columbia, Snake, and Sacramento rivers, as well as several rivers in Puget Sound watersheds (National Marine Fisheries Service and Washington Department of Fish and Wildlife 2018) and (National Marine Fisheries Service 2021e, Table 11).

4.9.3.1.5. Hatchery Production

Hatchery production is a significant component of the salmon prey base returning to watersheds within the range of SRKWs (Barnett-Johnson et al. 2007, National Marine Fisheries Service 2008d). The release of hatchery fish has not been identified as a threat to the survival or persistence of SRKWs, and there is no evidence to suggest that the whales prefer wild salmon over hatchery salmon. Increased Chinook salmon abundance, including hatchery fish, benefit this endangered population of whales by enhancing prey availability to SRKWs, and hatchery fish often contribute significantly to the salmon stocks consumed (Hanson et al. 2010b). Currently, hatchery fish play a mitigation role of helping sustain Chinook salmon numbers while other, longer-term recovery actions for natural fish are underway. Although hatchery production has contributed to offset some of the historical declines in the abundance of natural-origin salmon within the range of the whales, hatcheries also pose risks to natural-origin salmon populations (Nickelson 1986, Ford 2002, Levin 2002, Naish et al. 2007). However, measures have been implemented to mitigate these risks, such as the development of hatchery genetic management plans (HGMPs). The Priority Chinook Stocks report (National Marine Fisheries Service and Washington Department of Fish and Wildlife 2018) has been used in federal and state decision-making for prioritizing Chinook salmon stock production to increase the SRKW prey base.

4.9.3.2. Nutritional Limitation and Body Condition

When prey is scarce or in low density, SRKWs likely spend more time foraging than when prey is plentiful or in high density. Increased energy expenditure and prey limitation can cause poor body condition and nutritional stress, which is the condition of being unable to acquire adequate

[10] https://media.fisheries.noaa.gov/dam-migration/srkw_priority_chinook_stocks_conceptual_model_report___list_22june2018.pdf

energy and nutrients from prey resources. As a chronic condition, it can lead to reduced body size of individuals and lower reproductive and survival rates in a population (Trites and Donnelly 2003). During periods of nutritional stress and poor body condition, cetaceans lose adipose tissue behind the cranium, displaying a condition known as "peanut-head" in extreme cases (Pettis et al. 2004, Bradford et al. 2012, Joblon et al. 2014). Between 1994 and 2008, 13 SRKWs (males and females across a range of ages) were observed from boats to have a pronounced "peanut-head," or sunken neck, and all but two subsequently died (Center for Whale Research 2008, Durban et al. 2009). None of the whales that died were subsequently recovered, and therefore the definitive cause of death could not be identified.

Since 2008, NMFS' SWFSC has used aerial photogrammetry to assess the body condition and health of SRKWs, initially in collaboration with the CWR and the Vancouver Aquarium and, more recently, with SR^3 SeaLife Response, Rehabilitation, and Research. Aerial photogrammetry studies have provided finer resolution for detecting poor condition, before malnutrition manifests in the "peanut heads" observable from boats. Annual aerial surveys of the population from 2013 to 2017 (with exception of 2014) have detected declines in body condition before the death of seven SRKWs (L52 and J8 as reported in Fearnbach et al. [2018]; J14, J2, J28, J54, and J52 as reported in and Trites and Rosen [2018]). However, these studies used a body condition metric that is variable across the growth stages and may not accurately represent improving or declining health (Fearnbach et al. 2019). Furthermore, morphometric body condition assessments do not provide information on the cause of reduced body condition. In one study, a hormone analysis from fecal samples suggested that prey availability may be a greater physiological stressor on SRKWs than vessel presence due to differences in concentrations of glucocorticoids and a thyroid hormone (Ayres et al. 2012). However, hormone concentrations vary naturally by season, as do vessels and prey availability, which potentially confounds interpretation of these results.

A recent study utilized seven years of aerial photographs and documented body condition in individual SRKWs over time (99 individuals across all three pods, Stewart et al. 2021) using the eye patch ratio, which measures the fatness behind the cranium and is robust to variation in surfacing orientation and changes in body proportions with growth (Fearnbach et al. 2019). Importantly, the authors used age- and sex-normalized body condition classes to account for variability in size and nutritive condition. Generally, (Stewart et al. 2021) found that whales in poor body condition had mortality probabilities two to three times higher than whales in more robust condition. The authors also examined several variables to estimate the probability that an individual whale's body condition would improve, decline, or remain stable across years, given the estimated Chinook salmon abundance of the previous year. Fraser River and Salish Sea Chinook salmon stocks showed the greatest predictive power with J pod body condition, showing a strong negative relationship between the probability of body condition decline and Chinook salmon abundance (Stewart et al. 2021). L pod body condition was better explained by Puget Sound Chinook salmon abundance, though the relationship was weaker than the relationship between J pod body condition and Fraser Chinook salmon abundance. The relationship with L pod was difficult to interpret. L pod spends less time in the Salish Sea than J pod (especially in the most recent decade) and Puget Sound Chinook salmon are outnumbered by other Chinook salmon stocks in the North of Falcon[11] areas. For K pod, the best model did not

[11]The North of Falcon management area encompasses the Washington coast and northern Oregon (the coastal waters from the United States/Canadian border to Cape Falcon, Oregon).

include any Chinook salmon abundance covariates, and body condition was relatively constant over time. However, the models including Chinook salmon abundance generally performed only marginally better than the null model, suggesting other factors may contribute to body condition shifts. In another recent paper, the probability of prey capture was reduced for SRKWs when salmon abundance was lower and when the speed of nearby vessels was faster (Holt et al. 2021a), suggesting that there may be multiple pathways to nutritional stress when prey is limited.

A recent paper aimed to quantify differences in prey availability between the declining SRKW population and the growing NRKW population, both of which rely heavily on Chinook salmon but occupy adjacent and minimally overlapping habitats. Acoustic methods were used to identify the prey field along predetermined transects (Sato et al. 2021). In the summer months (July–August) of 2018 and 2019, the study found comparable prey patch frequencies and prey size between the two habitats, but that that prey density within patches was higher in SRKW habitat compared to NRKW habitat (Sato et al. 2021). The portion of SRKW habitat surveyed in this study includes areas in the Strait of Juan de Fuca where some prey samples have been collected along Vancouver Island, British Columbia (Hanson et al. 2010a), and where recent observations have identified travel as the predominant behavior (Fisheries and Oceans Canada 2021). (Sato et al. 2021) identified challenges in using acoustic methods to evaluate prey fields and noted other factors that were not analyzed, such as prey energy content or how vessel presence or sound may influence accessibility of prey. A recent paper by (Couture et al. 2022) modeled bioenergetics of SRKWs and found the population to be in an energetic deficit in six of the last 40 years, looking at Chinook as well as chum and coho salmon, and that abundance of age-4 and 5 Chinook salmon was the most important factor (of what was modeled) in whether SRKW energetic needs were met. Prey availability is highly variable and the dynamics of prey limitation for SRKW are still unclear; for example, times or locations where prey are most limiting and whether prey patch frequency or prey patch density is more important for killer whale foraging ecology are unknown.

Foraging ecology of SRKW and NRKW populations also differs in several ways, which may be tied to prey availability, social differences, or other factors. Tennessen et al. (2023) found that SRKW females foraged less (spent less time and captured less prey) than SRKW males, but the opposite was true for NRKWs. Additionally, females with calves captured less prey in both populations, but the pattern was stronger for SRKWs (Tennessen et al. 2023). It is unclear what the drivers and outcomes are of these different behavioral strategies and if they relate to broader population trends.

A scientific review investigating nutritional stress as a cause of poor body condition for SRKWs concluded “unless a large fraction of the population experienced poor condition in a particular year, and there was ancillary information suggesting a shortage of prey in that same year, malnutrition remains only one of several possible causes of poor condition” (Hilborn et al. 2012). Recent work has suggested that SRKW condition may deteriorate during the winter months. Aerial photogrammetry analyses from 2015 to 2017 found reduced body condition for J pod whales in May as compared to the previous September, soon after SRKW have foraged on summer salmon runs (Fearnbach et al. 2019). While prey limitation during the winter has been hypothesized as one reason for greater diversity seen in the diet (Hanson et al. 2021), there may be several reasons for seasonal body condition changes (and poor body condition has also been observed in September; Stewart et al. (2021). Ford and Ellis (2006) report that resident killer

whales engage in prey sharing about 76 percent of the time. Prey sharing presumably would distribute more evenly the effects of prey limitation across individuals of the population than would otherwise be the case (i.e., if the most successful foragers did not share with other individuals), so that effects of low prey availability may not be seen until prey is extremely low and may be observed in multiple individuals at the same time. Body condition and malnutrition in whales can be influenced by a number of factors, including reduced prey availability, reduced ability to successfully forage, increased energy demands, physiological or life history status, disease, or reduced intestinal absorption of nutrients (Raverty et al. 2020).

It is possible that poor nutrition could contribute to mortality through a variety of mechanisms. To exhibit how this is possible, we reference studies that have demonstrated the effects of energetic stress (caused by incremental increases in energy expenditures or incremental reductions in available energy) on adult females and juveniles, which have been studied extensively (e.g., adult females: Gamel et al. [2005], Schaefer [1996], and Daan et al. [1996]; juveniles: Noren et al. [2009] and Trites and Donnelly [2003]). Small, incremental increases in energy demands should have the same effect on an animal's energy budget as small, incremental reductions in available energy, such as one would expect from reductions in prey. Malnutrition and persistent or chronic stress can induce changes in immune function in mammals and may be associated with increased bacterial and viral infections (Neale et al. 2005, Mongillo et al. 2016, Maggini et al. 2018).

Reduced body condition and body size has been observed in the NRKW population as well. For example, Groskreutz et al. (2019) used aerial photogrammetry from 2014 to 2017 to measure growth and length in adult NRKWs, which prey on similar runs of Chinook salmon. Given that killer whales physically mature at age 20 and the body stops growing (Noren 2011), we would expect adult male killer whales to all have similar body lengths and all adult female killer whales to have similar body lengths. However, Groskreutz et al. (2019) found that whales aged 20-40 years have significantly shorter body lengths than those older than 40 years of age, suggesting the younger mature adults had experienced inhibited growth. Similarly, adult SRKWs under 30 years of age that were measured in 2008 by the same photogrammetric technique were also shorter on average than older individuals, suggesting reduced growth in more recent years (Fearnbach et al. 2011).

High mortality occurred in both resident killer whale populations in the 1990s, which was a time when range-wide abundance of Chinook salmon in multiple subsequent years fell below the 1979–2003 average (Figure 29), (Ford et al. 2010a). The low Chinook salmon abundance and smaller growth in whale body size coincided with an almost 20 percent decline from 1995 to 2001 (from 98 whales to 81 whales) in the SRKW population (National Marine Fisheries Service 2008d). During this period of decline, multiple deaths occurred in all three SRKW pods and relatively poor survival occurred in nearly all age classes and in both males and females. NRKWs also experienced population declines during the late 1990s and early 2000s. Hilborn et al. (2012) stated that periods of decline across killer whale populations "suggest a likely common causal factor influencing their population demographics" (Hilborn et al. 2012). Overall, evidence of reduced growth and poor survival in SRKW and NRKW populations at a time when Chinook salmon abundance was low suggests that low prey availability may have contributed to nutritional deficiency with serious effects on individual whales.

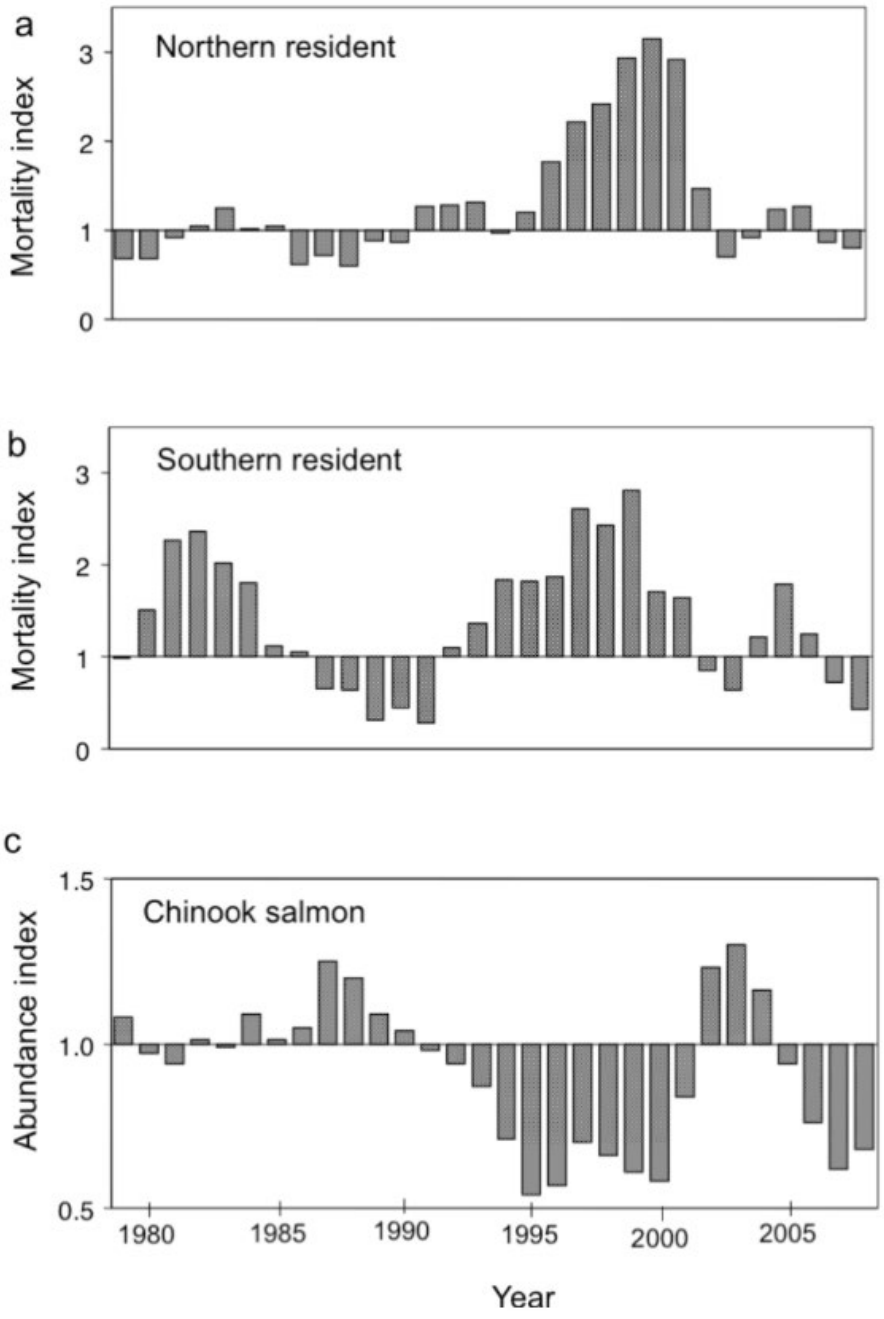


Figure 29. Annual mortality indices for a) Northern Resident and b) Southern Resident killer whales, and c) abundance index of Chinook salmon from 1979 to 2003.

Source: reprinted from (Ford et al. 2010b)

During this same general period of time of low Chinook salmon abundance, declining body size in whales, and declining resident killer whale populations, all three SRKW pods experienced substantially low social cohesion (Parsons et al. 2009). This temporal shift in SRKW social

cohesion may reflect a response to changes in prey. Similarly, Foster et al. (2012) found that from 1984 to 2007, the SRKW social network was more interconnected in years of higher Chinook salmon abundance. The authors suggest that years with higher Chinook salmon abundance may lead to more opportunities for mating and information transfer between individuals.

For many animals, the distribution and abundance of prey is one of the most important factors influencing social structure (Parsons et al. 2009). In social animals at an optimal group size, "group fissioning" could be one response to reduced prey abundance. However, the benefits of cooperative care or food sharing might outweigh the cost of the large group size. Parsons et al. (2009) note that smaller divisions within the pod's matrilines may temporarily occur in SRKWs as opposed to true fission, but this warrants further investigation. Given the highly social nature of SRKWs, socially-mediated fitness outcomes of nutritional limitation could be important.

4.9.3.3. Toxic Chemicals

Various adverse health effects in humans, laboratory animals, and wildlife have been associated with exposures to persistent pollutants. These pollutants have the ability to cause endocrine disruption, reproductive disruption or failure, immunotoxicity, neurotoxicity, neurobehavioral disruption, and cancer (Reijnders 1986, Subramanian et al. 1987, de Swart et al. 1996, Bonefeld-Jørgensen et al. 2001, Reddy et al. 2001, Schwacke et al. 2002, Darnerud 2003, 2008, Legler and Brouwer 2003, Viberg et al. 2003, Ylitalo et al. 2005, Fonnum et al. 2006, Viberg et al. 2006, Legler 2008). SRKWs are exposed to a mixture of pollutants, some of which may interact synergistically and enhance toxicity, influencing their health and reproduction. Relatively high levels of these pollutants have been measured in blubber biopsy samples from SRKWs compared to other resident killer whales in the North Pacific (Ross et al. 2000, Krahn et al. 2007, Krahn et al. 2009, Lawson et al. 2020). More recently, these pollutants were measured in fecal samples collected from SRKWs, and fecal toxicants matched those of blubber samples, which provides another resource to evaluate exposure to these pollutants (Lundin et al. 2016a, Lundin et al. 2016b). Recent work by Lee et al. (2023a) quantified the presence of multiple emerging contaminants in the tissues of stranded SRKW and Bigg's (transient) killer whales, including in fetuses and calves of SRKW. Alkylphenols and polyfluoroalkyl substances were the most prevalent compounds. Concentration of the contaminant 4-nonylphenol was significantly higher in SRKW calf samples than in Bigg's, and a major source of 4-nonylphenol is toilet paper, which could be related to proximity to sewage effluent.

SRKWs are exposed to persistent pollutants primarily through their diet. For example, Chinook salmon contain higher levels of some persistent pollutants than other salmon species, but only limited information is available for pollutant levels in Chinook salmon (Krahn et al. 2007, O'Neill and West 2009, Veldhoen et al. 2010, Mongillo et al. 2016). These harmful pollutants, through consumption of prey species that contain these pollutants, are stored in the blubber and can later be released. When the pollutants are released, they are redistributed to other tissues when the whales metabolize the blubber, for example, in response to food shortages or reduced acquisition of food energy. The release of pollutants can also occur during gestation or lactation, exposing calves to contaminants (and temporarily reducing the burden for lactating females). Once the pollutants mobilize into circulation, they have the potential to cause a toxic response. Fecal samples showed that toxicants were highest in concentration when prey availability was low, and the possibility of toxicity was therefore highest with low prey (Lundin et al. 2016b).

Therefore, nutritional stress from reduced prey, including Chinook salmon populations, that may occur or may be occurring, may act synergistically with high pollutant levels in SRKWs and result in adverse health effects.

4.9.3.4. Disturbance from Vessels and Sound

Killer whales rely on their highly developed acoustic sensory system for navigating, locating prey, and communicating with other individuals. While in inland waters of Washington and British Columbia, SRKWs are the principal target species for the commercial whale watching industry (Hoyt 2001, O'Connor et al. 2009) and encounter a variety of other vessels in their urban environment (e.g., recreational, fishing, ferries, military, and shipping vessels). Several main threats from vessels include direct vessel strikes, the masking of echolocation and communication signals by anthropogenic sound, and behavioral changes (National Marine Fisheries Service 2008d). There is a growing body of evidence documenting effects from vessels on small cetaceans and other marine mammals (National Marine Fisheries Service 2010b, 2018g, 2021j). Research has shown that SRKWs spend more time traveling and performing surface active behaviors and less time foraging in the presence of all vessel types, including kayaks (Holt 2008, Lusseau et al. 2009, Noren et al. 2009, Williams et al. 2010). Furthermore, noise from and/or the presence of motoring vessels up to 400 meters away has the potential to affect the echolocation abilities of foraging whales and their foraging dives and success (Holt 2008, Lusseau et al. 2009, Noren et al. 2009, Williams et al. 2010, Holt et al. 2021a, Holt et al. 2021b), or probability of being in a foraging state (Williams et al. 2021). New models of SRKW behavioral states showed that both males and females spent less time in foraging states, with fewer prey-capture dives and less time spent in prey capture dives, when vessels were near (within 400 yards on average, Holt et al. 2021b). The impact was greater for females, who were more likely than males to switch from deep and intermediate dive foraging behaviors to travel/respiration states when vessels were near (Holt et al. 2021b).

Individual energy balance may be impacted when vessels are near the whales because of the increase in energetic costs resulting from (1) changes in activity, and (2) the decrease in prey consumption resulting from reduced foraging opportunities (Williams et al. 2006a, Lusseau et al. 2009, Noren et al. 2009, Noren et al. 2012, Noren and Hauser 2016, Holt et al. 2021a, Holt et al. 2021b). Some evidence indicates there is a higher energetic cost of surface active behaviors and vocal effort resulting from vessel disturbance in the Salish Sea (Williams et al. 2006b, Noren et al. 2012, Noren et al. 2013, Holt et al. 2015). However, reduced prey consumption is likely the more important factor impacted by vessels. In a recent study, SRKWs had a lower predicted probability of capturing prey when vessel speeds were higher nearby (within 1.5 kilometers, Holt et al. 2021a). Given that vessel speed is one of the strongest predictors of underwater noise (Houghton et al. 2015), faster moving vessels appear to have a greater impact on energy intake in SRKWs, including vessels located farther than the closest allowed distance (200–400 yards) for viewing the whales, and those beyond the current speed restriction distance (half nautical mile). However, it is difficult to determine the cumulative impacts of the multiple vessel approaches on individual whales and the population. Furthermore, the study found that prey capture dive duration and the speed of descent varied in the presence of echosounders emitted by vessels with received levels of noise and with vessel distance (Holt et al. 2021a). Importantly, the authors found that the probability of prey capture was positively correlated with prey abundance, suggesting that in years of low prey abundance, vessel impacts may compound the stressor of

food availability. In another study, vessel speed did not predict foraging behavior, but estimated levels of sound impacted the probability of foraging (Williams et al. 2021).

At the time of the SRKWs' listing under the ESA, NMFS reviewed existing protections for the whales and developed recovery actions, including vessel regulations, to address the threat of vessels to killer whales. NMFS concluded it was necessary and advisable to adopt regulations to protect killer whales from disturbance and sound associated with vessels to support recovery of SRKWs. Federal vessel regulations were established in 2011 to prohibit vessels from approaching killer whales within 200 yards (182.9 meters) and from parking in the path of the whales within 400 yards (365.8 meters). These regulations apply to all vessels in inland waters of Washington State with exemptions to maintain safe navigation and for government vessels in the course of official duties, ships in the shipping lanes, research vessels under permit, and vessels lawfully engaged in commercial or treaty Indian fishing that are actively setting, retrieving, or closely tending fishing gear (76 FR 20870).

In the final rule implementing these regulations, NMFS committed to (1) review the regulations to evaluate effectiveness, and (2) study the impact of the regulations on the viability of the local whale watch industry. Education, enforcement, and monitoring efforts were documented to support the review, and the results were analyzed and published in a 2017 NMFS Technical Memo (Ferrara et al. 2017). The 2017 analysis evaluated the effectiveness of the vessel regulations using five key measures: education and outreach efforts, enforcement, vessel compliance, biological effectiveness, and economic impacts. For each measure, the analysis focused on the five years leading up to the regulations (2006–2010) and compared trends and observations to the five years following their implementation (2011–2015). (Ferrara et al. 2017) concluded that the regulations have provided some benefits to the whales; however, additional measures may be necessary to reduce the impacts of vessels on SRKWs. Although robust education and outreach efforts were in place in the years following the implementation of the regulations, awareness of the regulations among recreational boaters remained low, fluctuating around 45 percent of the boaters contacted by Soundwatch from 2011 to 2015. This was reflected in the compliance trends, which showed higher rates of incidents of noncompliance among recreational boaters than commercial whale watch operators (which remains true in 2022, see Frayne [2023]). Despite this trend in awareness, compliance with the regulations in the five years following the codification of the regulations was significantly higher in the presence of enforcement vessels, indicating an effective enforcement program. Although these regulations required commercial whale watch operators to change their behaviors around the whales, they did not result in adverse economic impacts to the industry from 2011 through 2015.

In 2019, Washington State regulations were updated to increase vessel viewing distances from 200 to 300 yards to the side of the whales and reduce vessel speed within a half nautical mile of the whales to seven knots over ground (Revised Code of Washington 77.15.740). Also, in 2019, NMFS conducted a scoping meeting and public comment period to gather input on whether existing regulations and other measures adequately protect killer whales from the impacts of vessels and noise in the inland waters of Washington State, and, if not, what actions NMFS should take (84 FR 57015).

In addition to vessels, underwater sound can be generated by a variety of other human activities, such as dredging, drilling, construction, seismic testing, and sonar (Richardson et al. 1995,

Gordon and Moscrop 1996, National Research Council 2003). Impacts from these sources can range from serious injury and mortality to changes in behavior. In other cetaceans, hormonal changes indicative of stress has been recorded in response to intense sound exposure (Romano et al. 2003). Chronic stress is known to induce harmful physiological conditions (including lowered immune function) in terrestrial mammals and likely does so in cetaceans (Gordon and Moscrop 1996).

4.9.3.5. Oil Spills

In the Northwest, SRKWs are the most vulnerable marine mammal population to the risks imposed by an oil spill due to their overall small population size, strong site fidelity to areas with high oil spill risk, large groups of individuals together at once, late reproductive maturity, low reproductive rate, and specialized diet, among other attributes (Jarvela-Rosenberger et al. 2017). Oil spills have occurred in the range of SRKWs in the past, most recently in August 2022 when a commercial fishing vessel sank near San Juan Island, but no SRKWs were seen near the oil sheen that was spilled. Oil can be discharged into the marine environment in any number of ways, including shipping accidents, refineries and associated production facilities, and pipelines. Despite many improvements in spill prevention since the late 1980s, much of the region inhabited by SRKWs remains at risk from serious spills because of the heavy volume of shipping traffic and proximity to petroleum refining centers.

If repeated ingestion of petroleum hydrocarbons by killer whales occurs, it would likely cause adverse effects, though long-term consequences are poorly understood. In marine mammals, acute exposure to petroleum products can cause changes in behavior and reduced activity, inflammation of the mucous membranes, lung congestion and disease, pneumonia, liver disorders, neurological damage, adrenal toxicity, reduced reproductive rates, and changes in immune function (Geraci and Aubin 1990, Schwacke et al. 2013, Venn-Watson et al. 2015, de Guise et al. 2017, Kellar et al. 2017). Exposure can also result in death and long-term effects on population viability (Matkin et al. 2008, Ziccardi et al. 2015). For example, 122 cetaceans stranded or were reported dead within 5 months following the Deepwater Horizon spill in the Gulf of Mexico (Ziccardi et al. 2015). An additional 785 cetaceans were found stranded from November 2010 to June 2013, which was declared an Unusual Mortality Event (Ziccardi et al. 2015). Previous PAH exposure estimates suggested SRKWs can be occasionally exposed to concerning levels (Lachmuth et al. 2011). More recently, Lundin et al. (2018) measured PAHs in whale fecal samples collected in inland waters of Washington between 2010 and 2013 and found low concentrations of the measured PAHs (<10 parts per billion (ppb), wet weight). However, PAHs were as high as 104 ppb in the first year of their study (2010) compared to the subsequent years. Although it is unclear the cause of this trend, higher levels were observed prior to the 2011 vessel regulations that increased the distance vessels could approach the whales. In addition, oil spills have the potential to adversely impact habitat and prey populations, and, therefore, may adversely affect SRKWs by reducing food availability.

4.9.3.6. Health, Strandings, and Causes of Mortality

Information collated on strandings for all killer whale ecotypes (Raverty et al. 2020)have also contributed to our knowledge of the impact of the threats on mortality. Across the Northeast Pacific, causes of death for stranded killer whales of various ages and ecotypes have included congenital defects, malnutrition and emaciation, infectious disease, bacterial infections, and

injury from blunt force trauma (Raverty et al. 2020). The authors examined stranding reports from 2004 to 2013 within the North Pacific Ocean and Hawaii and determined cause of death for 53 stranded whales, 22 of which had a definitive diagnosis for cause of death. They reported on both proximate (process, disease, or injury that led to death) and ultimate (final process that led to death) causes of death. They confirmed that three whales died from vessel strikes, including one SRKW (L98 who was habituated to humans), one transient, and one NRKW. Three others died of blunt force trauma with unknown origin (including L112 discussed below). In addition, one Alaskan resident killer whale calf died of sepsis as a result of ingestion and impalement of a halibut fishing hook (Raverty et al. 2020). A previous paper reported fishing hooks and/or lures in the stomachs of four stranded resident killer whale carcasses (two with hooks/lures for salmon fishing and two with Pacific halibut hooks, (Ford et al. 1998). Nutritional causes were identified in 11 whales as either the proximate (n = 5) or ultimate cause of death (n = 6, Raverty et al. 2020), though none of these whales were identified as SRKWs.

SRKW strandings in the last decade have contributed to our understanding of the health of the population. Transboundary partnerships have supported thorough necropsies of L112 in 2012, J32 in 2014, and L95 and J34 in 2016, which included testing for contaminant load, disease and pathogens, organ condition, and diet composition[12]. The cause of death of L112 was determined to be blunt force trauma to the head, however the source of the trauma (vessel strike, intraspecific aggression, or other unknown source) could not be established. In 2014, J32, an adult late- to near-term female killer whale, had stranded with moderate to fair body condition and had suffered in utero fetal loss and infection. In spring 2016, a young adult male, L95, was found to have died of a fungal infection related to a satellite tag deployment approximately 5 weeks prior to its death. In fall 2016 another young adult male, J34, found in the northern Georgia Strait died of blunt force trauma to the head, consistent with vessel strike (Raverty et al. 2020, Carretta et al. 2021).

In addition to aerial photogrammetry and stranding data, noninvasive sample collection may contribute to our understanding of health in the SRKW population. A recent study used 12 years of expelled mucus and exhaled breath samples collected noninvasively to study the microbiome communities (Rhodes et al. 2022). Several taxa were found to be unique in mucus and breath samples and not found in seawater samples, indicating the likely makeup of the SRKW microbiome. While some bacterial taxa included pathogenic species, future assessment is needed to determine the presence of infection (Rhodes et al. 2022). Also, a recent study by Gaydos et al. (2023) that utilized digital photographs of SRKWs determined that 99 percent of the population alive during 2004–2016 at some point had evidence of skin lesions. Additionally, the prevalence of the two most prominent skin lesion types increased in all three pods from 2004 to 2016, but it is currently unclear the health significance of these lesions.

The only known case of SRKW mortality due to fisheries is an adult male, L8, who got entangled in gillnet fishing gear and drowned in 1977 (Center for Whale Research 2015, Carretta et al. 2023). The entanglement occurred near southeastern Vancouver Island (Ford et al. 1998), and upon necropsy, 2 pounds of recreational fishing lures and lines were found in the stomach. It

[12] Reports for those necropsies are available at: http://www.westcoast.fisheries.noaa.gov/protected_species/marine_mammals/killer_whale/rpi_strandings.html.

was noted that some of the fishing gear found did not appear to be used locally at the time and the ingestion of the gear did not cause the death of the animal (Carretta et al. 2023).

Typically, killer whales are able to avoid nets by swimming around or underneath them (Jacobsen 1986, Matkin 1994), and not all entanglements automatically result in death. For example, J39, a young male killer whale in J pod, was observed with a salmon flasher hooked in his mouth during the summer of 2015 around the San Juan Islands, which subsequently fell out with no signs of injury or infection (Center for Whale Research 2015, Carretta et al. 2023).

Killer whale entanglements from other ecotypes have also been reported. One killer whale was reported interacting with a salmon gillnet in British Columbia in 1994, but did not get entangled (Guenther et al. 1995). Two killer whales have been recorded entangled in Dungeness crab commercial trap fishery gear off California (one in 2015 and one in 2016, National Marine Fisheries Service 2017a). In 2018, Fisheries and Oceans Canada disentangled a transient killer whale entangled in commercial prawn gear near Salt Spring Island, British Columbia (NMFS strandings data, unpublished). In 2013, a NRKW stranded in British Columbia and a fish hook was observed in its colon, but had no evidence of perforation or mucosal ulceration (Raverty et al. 2020).

4.9.4. Climate Change and Other Ecosystem Effects

The potential impacts of climate and oceanographic change on marine mammals would likely involve effects on habitat availability and food availability. Although few predictions of climate impacts on SRKWs have been made, it seems likely that any changes in weather and oceanographic conditions resulting in effects on salmon populations would have consequences for the whales. SRKWs might shift their distribution in response to climate-related changes in their salmon prey. Persistent pollutant bioaccumulation may also change because of changes in the food web (Alava et al. 2018).

Climatic conditions affect salmonid abundance, productivity, spatial structure, and diversity through direct and indirect impacts at all life stages (Independent Scientific Advisory Board 2007, Lindley et al. 2007, Crozier et al. 2008, Moyle et al. 2013, Wainwright and Weitkamp 2013). Studies examining the effects of long-term climate change to salmon populations have identified a number of common mechanisms by which climate variation is likely to influence salmon sustainability. These include direct effects of temperature such as mortality from heat stress, changes in growth and development rates, and disease resistance. Changes in the flow regime (especially flooding and low flow events) also affect survival and behavior. Expected behavioral responses include shifts in seasonal timing of important life history events, such as the adult migration, spawn timing, fry emergence timing, and the juvenile migration. Indirect effects on salmon mortality, growth rates and movement behavior are also expected to follow from changes in the freshwater habitat structure and the invertebrate and vertebrate community, which governs food supply and predation risk (Independent Scientific Advisory Board 2007, Crozier et al. 2008).

In the marine ecosystem, salmon may be affected by warmer water temperatures, increased stratification of the water column, intensity and timing changes of coastal upwelling, loss of coastal habitat due to sea level rise, ocean acidification, and changes in water quality and freshwater inputs (Independent Scientific Advisory Board 2007, Mauger et al. 2015). Salmon

marine migration patterns could be affected by climate-induced contraction of thermally suitable habitat. Abdul-Aziz et al. (2011) modeled changes in summer thermal ranges in the open ocean for Pacific salmon under multiple IPCC warming scenarios. For chum, pink, coho, sockeye and steelhead, they predicted contractions in suitable marine habitat of 30 to 50 percent by the 2080s, with an even larger contraction (86 to 88 percent) for Chinook salmon under the medium and high emissions scenarios. Northward range shifts are a climate response expected in many marine species, including salmon (Cheung et al. 2015). However, salmon populations are strongly differentiated in the northward extent of their ocean migration and hence would likely respond individualistically to widespread changes in sea surface temperature.

Recent analysis ranked the vulnerability of West Coast salmon stocks to climate change, and, of the top priority stocks for SRKWs (National Marine Fisheries Service and Washington Department of Fish and Wildlife 2018), California Central Valley Chinook salmon stocks, Snake River fall and spring/summer Chinook salmon, Puget Sound Chinook salmon, and spring-run Chinook salmon stocks in the interior Columbia and Willamette river basins were ranked as "high" or "very high" vulnerability to climate change (Crozier et al. 2019). In general, Chinook salmon, coho, and sockeye runs were more vulnerable and this stemmed from exposure to higher ocean and river temperatures as well as exposure to changes in flow regimes (including in relation to snowpack, upwelling, sea level rise, and flooding). However, certain Chinook salmon runs do have higher ability to adapt and/or cope with climate change due to high life history diversity in juveniles and adults (including both subyearling and yearling smolts, multiple migration timings), but diversity may be lost with future climate change. Overall, chum and pink salmon were less vulnerable to climate change because they spend less time in fresh water than other salmonids, and certain steelhead runs had more moderate vulnerability than many Chinook and coho runs because of higher resilience (Crozier et al. 2019). Additionally, substantial declines in abundance due to climate change are predicted for Snake River spring/summer Chinook over the next 2–3 decades based on recent life cycle modeling (National Marine Fisheries Service 2020c, Zabel and Jordan 2020). Furthermore, recent modeling research has shown variation in the impacts of marine warming on fall-run Chinook salmon distribution depending on stock, resulting in future regional declines or increases in salmon abundance. Shelton et al. (2020) used a Bayesian state-space model to model ocean distribution of fall-run Chinook salmon stocks in the Northeast Pacific paired with data on sea surface temperature associated with each stock and future ocean climate predictions to predict future distribution of Chinook salmon related to changing sea surface temperature in 2030–2090. In warm years (compared to cool), modeled Klamath River, Columbia River (upriver bright run, lower, middle), and Snake River stocks shifted further north, while CCV stock shifted south. Notably, Columbia River and Snake River fall-run Chinook are in the top 10 priority stocks for SRKWs (National Marine Fisheries Service and Washington Department of Fish and Wildlife 2018). Predicted future shifts in distributions due to warming led to future increases in ocean salmon abundance off Northern British Columbia and Central California; minimal changes off Oregon, Southern British Columbia, and Alaska; and declines in abundance off Washington and Northern California (Shelton et al. 2020).

In addition to long-term anthropogenic climate change, cyclic and year-to-year natural climate variability can also impact SRKWs by way of impacts on their prey, and this natural climate variability is likely heightened by climate change. For example, evidence suggests that marine survival among salmonids fluctuates in response to 20 to 30-year cycles of climatic conditions

and ocean productivity. Naturally occurring climatic patterns, such as the Pacific Decadal Oscillation, El Niño and La Niña events, and North Pacific Gyre Oscillation, can cause changes in ocean productivity that can affect productivity and survival of salmon (Mantua et al. 1997, Francis and Hengeveld 1998, Beamish et al. 1999, Hare et al. 1999, Benson and Trites 2002, Dalton et al. 2013, Kilduff et al. 2015), affecting the prey available to SRKWs (though relationships may be weakening, see Litzow et al. (2020). Prey species such as salmon are most likely to be affected through changes in food availability and oceanic survival (Benson and Trites 2002), with biological productivity increasing during cooler periods and decreasing during warmer periods (Hare et al. 1999, National Marine Fisheries Service 2008d). Also, range extensions were documented in many species from Southern California to Alaska during unusually warm water associated with "The Blob" in 2014 and 2015 (Bond et al. 2015, Di Lorenzo and Mantua 2016) and past strong El Niño events (Pearcy 2002, Fisher et al. 2015).

The frequency of these extreme climate conditions associated with El Niño events or heat "blobs" are predicted to increase in the future with climate change (greenhouse forcing, Di Lorenzo and Mantua 2016) Therefore, it is likely that long-term anthropogenic climate change would interact with inter-annual climate variability. Multiple modeling studies have predicted increases in the variability and frequency of extreme El Niño-Southern Oscillation events due to climate change (Cai et al. 2014, Cai et al. 2015, Wang et al. 2017, Cai et al. 2018). Modeled projections of future marine heat waves similar to "The Blob" have predicted decreases in salmon biomass and distribution shifts for salmon, particularly sockeye, in the Northeast Pacific (Cheung and Frölicher 2020). Evidence suggests that early marine survival for juvenile salmon is a critical phase in their survival and development into adults. The correlation between various environmental indices that track ocean conditions and salmon productivity in the Pacific Ocean, both on a broad and a local scale, provides an indication of the role they play in salmon survival in the ocean.

Despite a lack of research on direct impacts of climate change on SRKWs, we expect there would be impacts to prey availability and habitat suitability via the mechanisms discussed above.

4.10. Designated Critical Habitat for Southern Resident Killer Whale

Critical habitat for the SRKW DPS was first designated on November 29, 2006 (71 FR 69054) in inland waters of Washington State (Figure 30). NMFS published a final rule to revise SRKW critical habitat in 2021(86 FR 41668). This rule, which became effective on September 1, 2021, maintains the previously designated critical habitat in inland waters of Washington (Puget Sound; 71 FR 69054) and expands it to include six additional coastal critical habitat areas off the coast of Washington, Oregon, and California (additional approximately 15,910 square miles; Figure 31). Critical habitat includes approximately 2,560 square miles of inland waters of Washington in three specific areas: (1) the Summer Core Area in Haro Strait and waters around the San Juan Islands; (2) Puget Sound; and (3) the Strait of Juan de Fuca (Figure 30), as well as 15,910 square miles (41,207 square kilometers) of marine waters along the United States West Coast between the 20-foot (6.1 meters) depth contour and the 656.2-foot (200 meters) depth contour from the United States' international border with Canada south to Point Sur, California. Based on the natural history of SRKWs and their habitat needs, NMFS identified the following PBFs essential to conservation for critical habitat: (1) water quality to support growth and development; (2) prey species of sufficient quantity, quality and availability to support individual

growth, reproduction and development, as well as overall population growth; and (3) passage conditions to allow for migration, resting, and foraging.

Additional information on the PBFs essential to conservation can be found in the 2006 critical habitat final rule (71 FR 69054) and the recent 2021 critical habitat expansion final rule (86 FR 41668) and is incorporated into information provided in the status for the species. We briefly summarize information on each of the three features here and more detailed descriptions based on recent research findings are also included in the Final Biological Report that supports the 2021 critical habitat rule (National Marine Fisheries Service 2021h).



Figure 30. Southern Resident killer whale 2006 critical habitat designation.

Note: areas less than 20 feet deep (relative to extreme high water) are not designated as SRKW critical habitat.

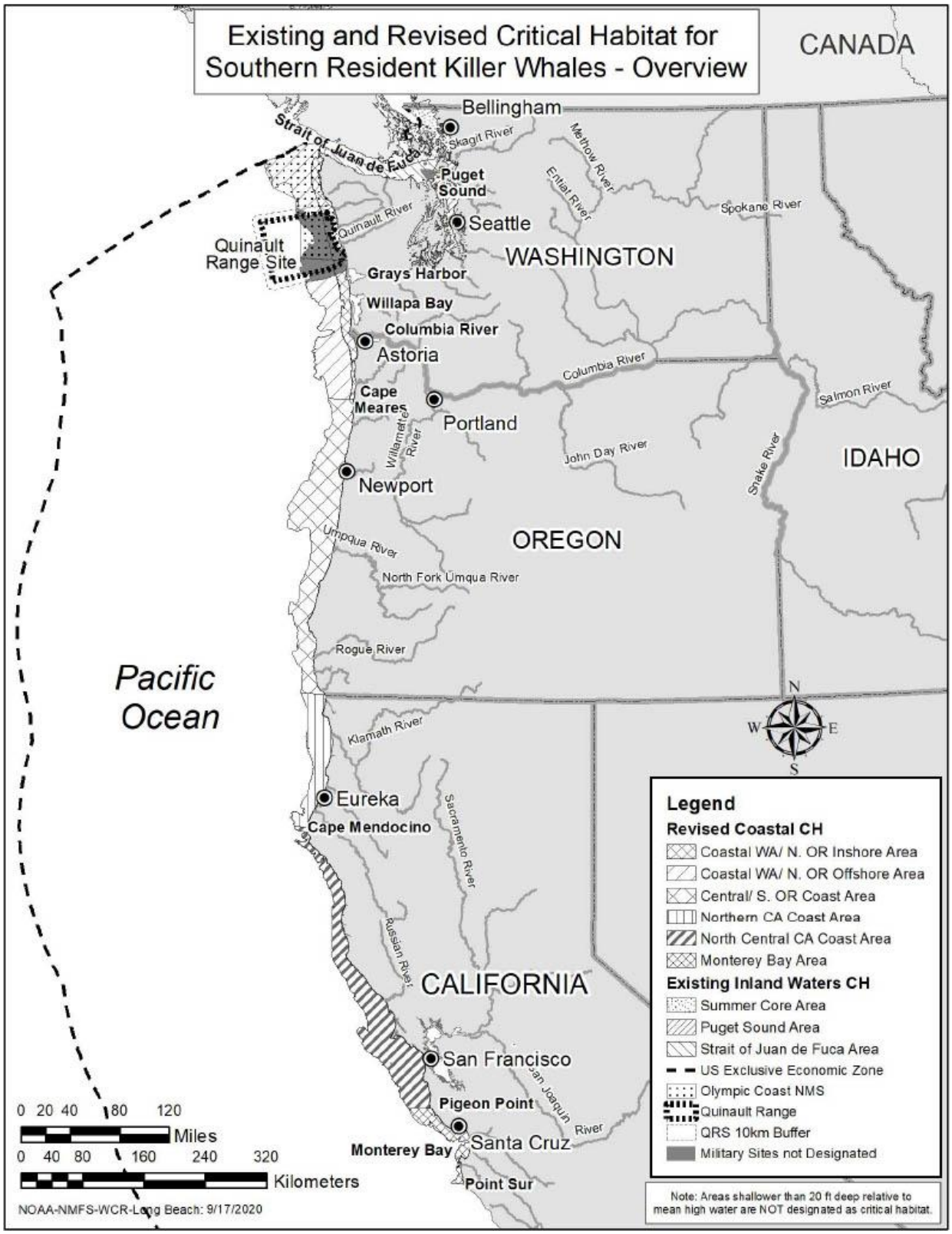


Figure 31. Specific areas of coastal critical habitat containing essential habitat features.

Source:(86 FR 41668)

4.10.1. Water Quality

Water quality is essential to SRKW conservation given the population's present contamination levels, small population numbers, increased extinction risk caused by any additional mortalities, and geographic range (and range of their primary prey), which includes highly populated and industrialized areas. Water quality is especially important in high-use areas where foraging behaviors occur and contaminants can enter the food chain. Water quality in the Puget Sound, in general, is degraded as described in the Puget Sound Partnership (PSP) 2022–2026 Action Agenda (Puget Sound Partnership 2022). For example, toxicants in the Puget Sound persist and build up in marine organisms, including SRKWs and their prey resources, despite bans in the 1970s of some harmful substances and cleanup efforts. Also, oil spill risk exists throughout the SRKW's coastal and inland range. The EPA and United States Coast Guard (USCG) oversee the Oil Pollution Prevention regulations promulgated under the authority of the Federal Water Pollution Control Act. There is a Northwest Area Contingency Plan, developed by the Northwest Area Committee, which serves as the primary guidance document for oil spill response in Washington and Oregon. In 2019, the Washington State Department of Ecology published a new Spill Prevention, Preparedness, and Response Program Annual Report describing the Spills Program as well as tracked performance measures from 2009 to 2019 (Washington State Department of Ecology 2019). In August 2022, a commercial fishing vessel sank off the west side of San Juan Island and an oil sheen was seen[13]. SRKW were not seen directly near the sheen but existing oil spill response plans were implemented and the Wildlife Branch of the Incident Command activated a Killer Whale Deterrence Team to prevent exposure.

4.10.2. Prey Quantity, Quality, and Availability

Prey species of sufficient quantity, quality, and availability are essential to conservation, as SRKWs need to maintain their energy balance all year long to support daily activities (foraging, traveling, resting, and socializing), as well as gestation, lactation, and growth. Most wild salmon stocks throughout the whales' geographic range are at fractions of their historic levels and 28 ESUs and DPSs of salmon and steelhead are listed as threatened or endangered under the ESA. Historically, overfishing, habitat losses, and hatchery practices were major causes of decline. Poor ocean conditions over the past two decades have reduced populations already weakened by the degradation and loss of freshwater and estuary habitat, fishing, hydropower system management, and hatchery practices. In addition to sufficient quantity of prey, fish need to be accessible and available to the whales, which can be related to the density and distribution of salmon and competition from other predators and fisheries.

Vessels and sound may reduce the effective zone of echolocation and also reduce availability of fish for the whales in their critical habitat (Holt 2008). As mentioned above, contaminants and pollution also affect the quality of SRKW prey in the Puget Sound and in coastal waters of Washington, Oregon, and California. The size of Chinook salmon is also an important aspect of prey quality (i.e., SRKWs primarily consume large Chinook), so changes in Chinook salmon size

[13] https://www.fisheries.noaa.gov/feature-story/coordinated-response-protected-southern-residents-sunken-ship-leaking-oil

(for instance, as shown by Ohlberger et al. [2018]) may affect the quality of this feature of critical habitat.

4.10.3. Passage

SRKWs require open waterways that are free from obstruction (e.g., physical and/or acoustic) to move within and migrate between important habitat areas throughout their range, communicate, find prey, and fulfill other life history requirements. In particular, vessels may present both physical and/or acoustic obstacles to whale passage, causing the whales to swim further and change direction more often, which can increase energy expenditure for whales and impacts foraging behavior (see Section 4.9.3.4 Disturbance from Vessels and Sound; National Marine Fisheries Service 2010b, Ferrara et al. 2017).

Human activities managed under a variety of legal mandates have the potential to affect the habitat features essential to the conservation of SRKWs, including those that could increase water contamination and/or chemical exposure, decrease the quantity, quality, or availability of prey, or inhibit safe, unrestricted passage between important habitat areas to find prey and fulfill other life history requirements. Examples of these types of activities include (but are not limited to), in no particular order: (1) salmon fisheries and bycatch; (2) salmon hatcheries; (3) offshore aquaculture/mariculture; (4) alternative energy development; (5) oil spills and response; (6) military activities; (7) vessel traffic; (8) dredging and dredge material disposal; (9) oil and gas exploration and production; (10) mineral mining (including sand and gravel mining); (11) geologic surveys (including seismic surveys); and (12) activities occurring adjacent to or upstream of critical habitat that may affect essential features, labeled "upstream activities" (including activities contributing to point-source water pollution, power plant operations, liquefied natural gas terminals, and desalinization plants; (National Marine Fisheries Service 2021h).

5. ACTION AREA

"Action area" means all areas to be affected directly or indirectly by the federal action and not merely the immediate area involved in the action (50 CFR 402.02). The action area for this consultation includes:

(1) Shasta and Keswick reservoirs, and the Sacramento River from Keswick Reservoir downstream to and including the Sacramento-San Joaquin Delta; (2) Whiskeytown Reservoir, and Clear Creek from Whiskeytown Reservoir to its confluence with the Sacramento River; (3) Folsom Reservoir, Lake Natoma, and the American River from Lake Natoma downstream to its confluence with the Sacramento River; (4) New Melones Reservoir, and the Stanislaus River from New Melones Reservoir to its confluence with the San Joaquin River; (5) the San Joaquin River from the confluence of the Stanislaus River downstream to and including the Sacramento-San Joaquin Delta; (6) San Francisco Bay and Suisun Marsh; and (7) the nearshore Pacific Ocean coastal areas off California, Oregon, and Washington where there is co-occurrence of Central Valley Chinook salmon and SRKWs. The action area also includes Spring Creek Debris Dam and Spring Creek.

6. ENVIRONMENTAL BASELINE

Environmental baseline refers to the condition of the listed species or its designated critical habitat in the action area, without the consequences to the listed species or designated critical habitat caused by the proposed action. The environmental baseline includes the past and present impacts of all federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed federal projects in the action area that have already undergone formal or early ESA section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process. The impacts to listed species or designated critical habitat from federal agency activities or existing federal agency facilities that are not within the agency's discretion to modify are part of the environmental baseline (50 CFR 402.02. The environmental baseline provides a description of the conditions during the time period associated with the effects of the proposed action. In accordance with NMFS guidance (Somma 2023), climate change is considered along with environmental variations in order to best characterize the future condition that the species will encounter. This section describes the past and ongoing factors leading to the status of ESA-listed species and the condition of their critical habitat within the action area.

In this opinion, the effects of past CVP and SWP operations are also part of the environmental baseline. Effects of those actions have been analyzed through past consultation and contributed to the current condition of the species and critical habitat in the action area. Other past, present, and ongoing impacts of human and natural factors (including proposed federal projects that have already undergone ESA section 7 consultation) contributing to the current condition of the species and critical habitat in the action area are also included in the environmental baseline.

Each time the operations of the CVP and SWP are consulted on (e.g., 2004, 2009, and 2019), the impacts of past and present operations of the CVP and SWP become part of the environmental baseline for subsequent consultations. Each past proposed action had specific components and operating criteria and were therefore separate federal actions requiring separate ESA section 7 consultations and analyses, although some ongoing components become incorporated into the proposed action considered in the next opinion. As such, Reclamation provided hydrologic modeling of the "No Action Alternative" (i.e., CalSim 3 modeling of operations determined by the 2020 ROD) as a modeling scenario that reflects the environmental baseline which includes the "past and present CVP and SWP operations." However, both the Reclamation and NMFS analyses recognize that the proposed action is not simply an ongoing action that projects the status quo into the future, but a new operational approach with a different suite of operational criteria and associated effects that must be distinguished and analyzed on their own. To better consider the effects of the action relative to future baseline conditions, Reclamation modeled "those ongoing operations that are not within the agencies' discretion to modify" (Reclamation 2023-2024) consistent with the definition of environmental baseline (50 CFR 402.02). In this modeling scenario (i.e., EXP3), Reclamation and DWR bypass inflows and make releases from reservoir storage where the flows otherwise in the system are insufficient to meet the following: (1) navigation and minimum instream flow requirements; (2) downstream senior water rights; (3) Exchange Contract demands from San Joaquin River flows and Refuge Level 2 demands; and (4) the revised 2000 Water Right Decision 1641 (D-1641) and other regulatory requirements. The EXP3 modeling scenario represents the obligated releases, and excludes discretionary operations. The EXP3 modeling described in Section 2.1.2 of the BA is that "EXP3 does not assume any

operation to comply with Order 90-5's water temperature objectives" (Reclamation 2023-2024). Ultimately, in NMFS' analysis of effects, we looked at both NAA modeling and EXP3 modeling as reference points to evaluate the "Proposed Future Operation of the CVP and SWP."

With respect to dams in NMFS' analysis of the proposed action, NMFS treats the existence of the CVP and SWP dams and their past operations as part of the baseline contributing to the status of the species. However, NMFS considers in the proposed action effects analysis how future daily, monthly, seasonal, and discretionary operational decisions to store or release water from CVP and SWP reservoirs can have effects downstream and through the Delta, relative to a future baseline condition that includes "Existing Structures and Non-Discretionary Operations." Depending on the flow, quality (e.g., temperature), timing, and location of the water released, as well as the life stage and species affected, these effects can be both beneficial and adverse.

Since settlement of the Central Valley in the mid-1800s, populations of native Chinook salmon, steelhead, and green sturgeon have declined dramatically, largely due to factors that completely reshaped the aquatic ecosystem, such as dam construction, water management, hydropower facilities, levee construction, and, before those, gold mining. These land use changes eliminated or blocked access to important habitats and reduced the abundance, productivity, and distribution of Central Valley salmonids and sturgeon. Habitat simplification, fishing, hatchery impacts, and other stressors led to the loss of genetic and phenotypic (life history, morphological, behavioral, and physiological) diversity in Central Valley salmonids, which has reduced their capacity to cope with a variable and changing climate (Herbold et al. 2018). Given the reliance of SRKWs on Chinook salmon prey resources that include Central Valley Chinook salmon, these factors have, and continue to, affect the available prey base of SRKWs. Land use changes to support and protect California's rapidly increasing human population combined with substantial and widespread water development, including the construction and operation of the CVP and SWP, have been accompanied by significant declines in nearly all species of native fish (State Water Resources Control Board 2017b). Evidence from a study that used a novel combination of tagging technologies suggests that the freshwater and estuarine environment has been so dramatically altered by habitat loss and water management that the anadromous life history strategy may no longer be sustainable for Central Valley salmon (Michel 2018).

Central Valley listed fish species are also culturally significant, as many tribes rely on the presence of a healthy ecosystem supporting these fish for their livelihood and for food, cultural, and ceremonial practices. The reduction of salmonid and sturgeon populations and landscape alterations have impacted California tribes. Dams, levees, land conversion, urbanization, water management, and gold mining are the main landscape-scale factors that have altered the Central Valley environment to what it is today, with climate change providing additional impacts. These landscape-scale factors and their impact on Central Valley listed species and critical habitat are discussed below, followed by a section on more localized, but also important, factors affecting listed species in the Central Valley.

6.1. Central Valley Project and State Water Project Operations and Existing Structures

Operations of dams across the Central Valley have resulted in major alteration of temperatures and flows through the year. Large amounts of water have historically been and currently are exported from throughout the Central Valley watershed to support agricultural, industrial, and

urban demands. Upstream water diversions combined with water exports in the Delta have reduced January to June outflows by an estimated 56 percent (average) and annual outflow by an estimated 52 percent (average). In the driest condition, in certain months outflows are reduced by more than 80 percent, January to June flows are reduced by more than 70 percent, and annual flows are reduced by more than 65 percent (State Water Resources Control Board 2017a).

Reclamation and DWR implement the coordinated operation of the CVP and SWP to maximize water supply delivery and optimize power generation consistent with applicable laws, contractual obligations, and agreements; and to increase operational flexibility by focusing on non-operational measures to avoid significant adverse effects based on the conditions estimated to occur through 2030. Reclamation and DWR store, divert, and convey water in accordance with existing water contracts and agreements, including water service and repayment contracts, settlement contracts, exchange contracts, and refuge deliveries, consistent with water rights and applicable laws and regulations.

The CVP and SWP is one of the world's largest water storage and conveyance systems with both the federal and the state portions of the projects capable of storing, diverting upstream, and exporting millions of acre-feet of water away from the Delta each year. The large volumes being exported through the South Delta combined with the location of the pumps in the South Delta result in significantly modified hydrologic and biological systems (Cummins et al. 2008).

The Environmental Baseline includes the past and current operation of the CVP and SWP and the presence of existing structures such as dams, reservoirs, export and fish salvage facilities, canals, and other related infrastructure. Past and current operations have gone through previous consultations with NMFS biological opinions that included either actions required through reasonable and prudent measures and terms and conditions that are also part of the Environmental Baseline (National Marine Fisheries Service 2004, 2009a, 2019b).

In 2004, NMFS issued a biological opinion concluding that the proposed action was not likely to jeopardize the continued existence of listed species or adversely modify their designated critical habitat. The biological opinion was challenged in 9th United States District Court (Court) and found to be arbitrary and capricious, and remanded to the agencies with directions to complete a new biological opinion. Following the remand, NMFS issued a revised biological opinion concluding that the proposed action was likely to jeopardize listed species or adversely modify their designated critical habitat. The 2009 Biological Opinion included an RPA with multiple RPA actions to address operational impacts to listed species and their critical habitat. Following reinitation by Reclamation, NMFS issued an October, 2019, Biological Opinion concluding that the proposed action was not likely to jeopardize listed species or adversely modify their designated critical habitat. The NMFS 2019 Biological Opinion was challenged in Federal District Court by PCFFA et al. and the California Natural Resources Agency, and in 2021, Reclamation requested reinitiation of consultation.

On November 23, 2021, in light of the reinitiated consultation, Federal Defendants (Reclamation, USFWS, and NMFS) requested a voluntary remand without vacatur of the 2019 Biological Opinions by NMFS and the USFWS and a stay through September 30, 2022 of both cases. On March 11, 2022, the Court vacated the NMFS 2019 Biological Opinion, without vacatur, and ordered Reclamation to operate to an Interim Operation Plan that governs the operation of the

Shasta and Delta Division through the end of the water year (September 30, 2022). Reclamation has been operating the Interim Operation Plans since and the most recent Interim Operation Plan will expire in December, 2024.

In operating the CVP and SWP, Reclamation and DWR must comply with certain statutory and regulatory requirements, including California water law. Applicable federal requirements include the Flood Control Act and regulations imposed by the United States Army Corps of Engineers (USACE), the Clean Water Act, the Central Valley Project Improvement Act (CVPIA), and the Reclamation Act.

The SWRCB has issued numerous decisions and orders conditioning Reclamation's water right permits and licenses that regulate Reclamation's operation of the CVP and DWR's operation of the SWP. Those terms and conditions are nondiscretionary obligations (including as may be revised or temporarily modified through a temporary urgency change order by the SWRCB) and must be complied with in order to exercise diversion and water use rights granted under CVP and SWP water right permits and licenses. One decision in particular, D-1641, affects the operation of numerous CVP and SWP facilities by requiring releases from upstream dams to meet downstream water quality objectives. Operations to meet the requirements of D-1641 are shared between the CVP and SWP under the *Coordinated Operations Agreement*. However, Reclamation does retain some ability to adjust operations of the CVP to balance the system and meet D-1641 and obligations under the *Coordinated Operations Agreement* with DWR.

Reclamation's BA describes that they do not have discretion to modify the existence of the dams; therefore, effects associated with the continued existence of those dams are attributed to the environmental baseline. According to Reclamation, in operating the CVP and SWP, Reclamation and DWR have the discretion to store inflow into CVP and SWP reservoirs (subject to nondiscretionary flood control and downstream requirements), release water (subject to channel capacities), divert water at CVP and SWP facilities, route water through CVP and SWP control structures, and blend water from different reservoir elevations to manage the available coldwater pool. Reclamation described their non-discretionary obligations in Appendix F of their BA (Reclamation 2023-2024).

Sacramento River

The CVP Shasta Division on the Sacramento River is managed for flood control, agricultural water supplies, M&I water supplies, fish and wildlife, hydroelectric power generation, Delta water quality, and water quality in the upper Sacramento River. Water rights, contracts, and agreements specific to the Upper Sacramento River include SWRCB Decisions 990, 90-5, 91-1, and 1641, Settlement Contracts, Exchange Contract, and Water Service Contracts.

Facilities include the Shasta Dam, Lake (4.552 million acre-feet [MAF] capacity), and Power Plant; Keswick Dam, Reservoir, and Power Plant; and the Shasta Temperature Control Device. The Sacramento Division includes the Red Bluff Pumping Plant, the Corning Pumping Plant, and the Corning and Tehama-Colusa Canals, for the irrigation of over 150,000 acres of land in Tehama, Glenn Colusa, and Yolo Counties. Shasta Dam is equipped with a temperature control device that allows temperature operations without impacting power generation. The temperature control device allows Reclamation to control the temperature of the water released from Shasta

Dam. The temperature control device has four levels of gates from which water can be drawn: the upper gates, middle gates, pressure relief gates (e.g., lower gates), and side gates (coldest configuration). The last tool to reduce temperatures is to operate the temperature control device in the full side gate position, drawing the lowest (and coldest) possible water from the reservoir.

According to Reclamation (2023-2024), the following non-discretionary actions and requirements apply to their operations:

- Major CVP facilities on the Sacramento River that are managed as part of the Shasta Division include the physical presence of Shasta Dam, Reservoir and Powerplant; and Keswick Dam, Reservoir and Powerplant.
- Reclamation operates Shasta and Keswick dams for flood control purposes in accordance with regulating criteria developed by the USACE in 1977.
- Minimum flows are required under Condition 24 of D-990. Reclamation operates Shasta Dam to bypass or release into the Sacramento River at Keswick Dam fish life flows, as provided in a 1960 Memorandum of Agreement with CDFG (now known as CDFW). In Order 90-05, the SWRCB modified the minimum flow requirements initially established in the 1960 Memorandum of Agreement. Order 90-5 set the minimum flow below Keswick Dam from September through February to be 3,250 cfs in all but critically dry water years. EXP3 assumes minimum flows will be provided in accordance with D-990 and Order 90-5.
- Temperature Objectives Below Keswick Dam are, in part governed by Order 90-5, which requires Reclamation to operate Shasta Dam, Keswick Dam, and the Spring Creek Power Plant, with certain exceptions, to meet a daily average water temperature of 56°F (13°C) in the Sacramento River at the Red Bluff Diversion Dam during periods when higher water temperatures will be detrimental to the fishery. While Reclamation must comply with those water temperature objectives, Order 90-5 allows Reclamation to identify alternative locations for the temperature compliance point if there are factors beyond the reasonable control of Reclamation that prevent meeting 56°F (13°C) at the Red Bluff Diversion Dam after consultation with CDFW, USFWS, NMFS, and the United States Western Area Power Administration. Water temperature operations at Shasta Dam require operation of the temperature control device located at the dam, and operation of the device is a daily operation that depends on the location of the temperature compliance point, the available coldwater pool in Shasta Reservoir, and other factors. Thus, there is considerable discretion in how to operate Shasta to meet Order 90-5.
- Reclamation operates Shasta and Keswick dams in coordination with other CVP and SWP facilities to comply with downstream D-1641 requirements.
- Reclamation operates Shasta Dam to deliver water to the SRSCs in accordance with the terms of the contracts. The SRSCs divert water directly from the Sacramento River through private facilities at various locations below Shasta Dam. Reclamation administers 132 SRS Contracts that provide for the diversion of approximately 2.09 MAF of water annually. The contract total is automatically reduced by 25 percent in a Shasta critical water year.
- Reclamation administers two agreements that provide for the delivery of up to 151,250 acre-feet annually of water to meet the Level 2 refuge water supply demands of North of Delta wildlife refuges.

Operational elements that affect ESA-listed species and their critical habitat on the Sacramento River include reservoir storage and water temperature management, ramping rates to minimize juvenile stranding from managed flow fluctuations, seasonal pulse flows to improve juvenile survival and flow management in the fall and winter to minimize redd stranding and dewatering and flow management to build storage for the following spring. Flow fluctuations from past and current Sacramento River operations have resulted in stranding of juvenile salmonids, Chinook salmon redd dewatering, and redd scour in the Sacramento River.

Droughts in 2014 to 2015 and again in 2021 to 2022 had significant adverse consequences on reservoir storage, water temperatures and survival of SR winter-run Chinook salmon. In 2014 and 2015, average temperature dependent mortality of incubating SR winter-run Chinook salmon eggs was 77 and 86 percent, respectively, and in 2021 and 2022, TDM averaged 75 and 17 percent. Significant actions were taken to conserve storage and manage water temperatures in 2022, the thiamine deficiency and other sources of background mortality decimated juvenile survival and the juvenile production estimate (JPE) of fish entering the Delta was only about 50,000.

Clear Creek

Reclamation operates Whiskeytown Reservoir to: (1) regulate inflows for power generation and recreation; (2) support upper Sacramento River temperature objectives; and (3) provide for releases to Clear Creek, as proposed below. Two temperature curtains in Whiskeytown Reservoir are installed to pass cold water through the bottom layer of the reservoir and limit warming from Carr power plant to Clear Creek or Spring Creek Power Plant.

According to Reclamation (2023-2024), the following non-discretionary actions and requirements apply to their operations:

- Whiskeytown Dam, which forms Whiskeytown Reservoir on Clear Creek, is a structure whose physical presence is included in the Environmental Baseline.
- Reclamation operates Whiskeytown Dam in coordination with other CVP and SWP facilities to comply with downstream D-1641 requirements.
- Minimum flows for Clear Creek are provided in existing memorandums of agreements or water rights agreements with the State of California, Reclamation, and the USFWS.
- Exchange contracts provide the delivery of up to 14,100 acre-feet of substitute water from CVP facilities.

Under Reclamation's 2020 proposed action, Reclamation proposed to manage Whiskeytown Dam releases to meet a daily average water temperature of: (1) 60°F at the Igo gauge from June 1 through September 15; and (2) 56°F or less at the Igo gauge from September 16 to October 31. These temperature objectives support holding, spawning and rearing habitat for CV spring-run Chinook salmon and steelhead. During the most recent drought, water temperature management was challenging but conditions were considered suitable for translocated CV spring-run Chinook salmon from the warm waters of the Sacramento River. Clear Creek serves an important role in the recovery of the CV spring-run Chinook salmon ESU by providing habitat for the only Core 1 population of CV spring-run Chinook salmon in the Basalt and Porous Lava diversity group.

American River

Reclamation operates the CVP American River Division for flood control, M&I and agricultural water supplies, hydroelectric power generation, fish and wildlife protection, recreation, and Delta water quality. Facilities include the Folsom Dam, reservoir (977 thousand acre-feet [TAF] capacity), the temperature control shutters on the power plant intakes for Folsom Dam, power plant, urban water supply temperature control device, and the Joint Federal Project auxiliary spillway as well as the Nimbus Dam, Lake Natoma, Nimbus Power Plant, and Folsom South Canal.

Major CVP facilities on the American River include the physical presence of Folsom Dam, Reservoir and Power Plant; Nimbus Dam, Lake Natoma and Nimbus Power Plant; and the Folsom South Canal.

According to Reclamation (2023-2024), the following non-discretionary actions and requirements apply to their operations:

- In operating Folsom Reservoir, Reclamation complies with regulatory requirements imposed by the USACE. In 2017, Reclamation and the USACE completed the Folsom Dam Auxiliary Spillway Project, which is also known as the Joint Federal Project, to improve flood control operations at Folsom. In 2019, the USACE issued a new Water Control Manual, which utilizes forecasted inflow as the criteria for determining flood control releases.
- Reclamation complies with minimum flow requirements as provided for in D-893. In that decision, the SWRCB set the minimum allowable flows in the Lower American River, in the interest of fish conservation, such that they should not ordinarily fall below 250 cfs between January 1 and September 15 or below 500 cfs at other times.
- Reclamation operates Folsom and Nimbus dams in coordination with other CVP and SWP facilities to comply with downstream D-1641 requirements.
- Reclamation administers five contracts that provide for the diversion of non-project water by contractors that hold water rights that are senior to those of the United States. In total, those contracts provide for the annual diversion of up to 430,000 acre-feet of water from the American River and up to 81,800 acre-feet of water from the Sacramento River. Reclamation also administers a Memorandum of Understanding with the California Department of Corrections for the annual diversion of up to 5,000 acre-feet of water for Folsom State Prison. Those contracts do not include standard water shortage provisions found in water service contracts, nor do they include critical year shortage provisions, like those found in the SRS Contracts.

Managed flows, while providing benefits such as water supply and flood protection, also result in changes to river function and geomorphic processes that help to maintain habitat conditions suitable for spawning and rearing. Gravel augmentation efforts on the Lower American River are designed to increase the quality and quantity of salmonid habitat (Merz et al. 2017). Flow fluctuations from past and current American River operations have resulted in stranding of juvenile CCV steelhead, redd dewatering, and redd scour in the American River. The frequency of redd-scouring flows is expected to be slightly lower with completion of the Folsom Dam and Lake Water Control Manual (National Marine Fisheries Service 2018d).

Since 2020, Reclamation has managed the Folsom/Nimbus Dam complex and the water temperature control shutters at Folsom Dam with the objective of maintaining a daily average water temperature of 65°F (or other temperature as determined by the temperature modeling) or lower at Watt Avenue Bridge from May 15 through October 31 to provide suitable conditions for juvenile CCV steelhead rearing in the lower American River, as long as cold water is available. Despite the water temperature planning mechanisms in place on the American River, water temperature management for CCV steelhead is challenging, especially during drought years when low Folsom storage results in an extremely limited cold-water pool. In many years, Reclamation has initiated power bypass actions to access the coldest remaining water at the bottom of Folsom Reservoir to provide more suitable water temperature conditions in October and November, but even those actions do not fully address water temperature challenges in the basin. In 2021 (and also in 2014 and 2015) drought conditions resulted in the Nimbus Fish Hatchery water temperatures and dissolved oxygen conditions to be so poor that fish were released early into the river or translocated to other hatcheries.

Stanislaus and the Lower San Joaquin Rivers

Reclamation operates the CVP East Side Division, including the Stanislaus River and the Lower San Joaquin River for flood control, agricultural water supplies, hydroelectric power generation, fish and wildlife protection, and recreation. In the Stanislaus River watershed, Reclamation owns and operates New Melones Dam and Reservoir (2.4 MAF capacity). The Tri-Dam Project, a partnership between the Oakdale Irrigation District and South San Joaquin Irrigation District, consists of Donnells and Beardsley dams, located upstream of New Melones Reservoir on the middle fork Stanislaus River, and Tulloch Dam and Powerplant, located approximately 6 miles downstream of New Melones Dam on the mainstem Stanislaus River. Releases from Donnells and Beardsley dams affect inflows to New Melones Reservoir. The main water diversion point on the Stanislaus River is Goodwin Dam, located approximately 2 miles downstream of Tulloch Dam. The Oakdale Irrigation District and South San Joaquin Irrigation District manage the Tulloch and Goodwin Dam infrastructure through separate agreements with both Reclamation and Reclamation's CVP water service contractors (Stockton East Water District and the Central San Joaquin Water Conservation District) to meet Reclamation's Stanislaus River objectives, CVP contractor deliveries, and deliveries to the Oakdale Irrigation District and South San Joaquin Irrigation District service areas. Reclamation also operates Friant Dam on the San Joaquin River, which creates Millerton Lake (520 TAF capacity) and releases are made to divert water into the Madera and Friant-Kern Canals for water supply purposes.

The Stanislaus River watershed has annual obligations that exceed the average annual runoff in a given year due to several factors, including SWRCB water rights decisions D-1641, D-1422 and D- 1616, the 1987 CDFG agreement, CVPIA objectives, the 2009 Biological Opinion, the 1988 Agreement and Stipulation with the Oakdale Irrigation District and South San Joaquin Irrigation District, riparian water right diverters, and CVP water delivery contracts.

According to Reclamation (2023-2024), the following non-discretionary actions and requirements apply to their operations:

- Reclamation owns and operates New Melones Dam, which creates New Melones Reservoir and is part of the East Side Division, which also includes two non-federal downstream dams: Tulloch and Goodwin.
- Reclamation operates New Melones Dam in accordance with the water control manual issued by the USACE in 1980 and a flood diagram issued in 1982. The New Melones Reservoir flood control operation is coordinated with the operation of Tulloch Reservoir. The flood control objective is to maintain flood flows at the Orange Blossom Bridge at less than 8,000 cfs. When possible, however, releases from Tulloch Dam are maintained at levels that would not result in long-term downstream flows over 1,500 cfs because of the past reported potential for seepage in agricultural lands adjoining the river associated with flows above this level. Up to 10,000 acre-feet of Tulloch Reservoir storage is set aside for flood control.
- The SWRCB's D-1422 provides that a dissolved oxygen concentration be maintained in the Stanislaus River as specified in the Water Quality Control Plan (Interim), San Joaquin River Basin 5C, SWRCB, June 1971. The SWRCB's D-1641 also requires Reclamation to maintain a dissolved oxygen concentration in the Stanislaus River as specified in the Water Quality Control Plan for the Sacramento and San Joaquin River Basins. The Central Valley Regional Water Quality Control Board (2019) designates the lower Stanislaus River with cold water and spawning beneficial uses, which have a general water quality objective of no less than 7 milligrams per liter dissolved oxygen.
- SWRCB D-1641 requires Reclamation to "maintain the Vernalis agricultural salinity objective specified in Table 2" of D-1641. Those standards are to be met on an "interim basis […] until the Board adopts a further decision in the Bay-Delta Water Rights Hearing assigning responsibility for meeting these objectives." SWRCB D-1641 also requires, "on an interim basis until the Board adopts a decision assigning permanent responsibility for meeting the water quality objectives," that Reclamation ensure that the fish and wildlife objectives for San Joaquin River flow at Airport Way Bridge, Vernalis, as stated in Table 3 of D-1641, is met. However, Reclamation's BA states that since the expiration of the San Joaquin River Agreement, there is no viable plan of implementation for Reclamation to solely implement Table 3 flows without contribution from other tributaries.

Generally, the facilities and operations in the Stanislaus and Lower San Joaquin rivers, up until the initiation of this consultation, have contributed to conditions that have continued to limit the resilience of the ESA-listed species found therein. Under the 2020 ROD, Reclamation operates New Melones Reservoir to provide minimum releases at Goodwin Dam according to a Stepped Release Plan (SRP) with annual release volumes dictated by water year type. In wet year conditions, natural, unimpaired peak flows of 25,000 cfs to 30,000 cfs have been reduced to less than 5,000 cfs by reservoir operations. Likewise, in dry year conditions, unimpaired peak flows of 7,000 cfs to 8,000 cfs have been reduced to less than 1,500 cfs. Notably in 2019, Reclamation changed the method used to determine year type using the "60-20-20" Index for the San Joaquin Valley Water Year Hydrologic Classification (based on the current water year's hydrology and the previous year's index), rather than the New Melones Index (based on end-of-February New Melones storage and March-September inflow to New Melones) used previously. Other than those changes, operations on the Stanislaus River and those affecting the conditions in the Lower San Joaquin River have

remained largely unchanged over the last decade.

Similar to the relative consistency with which Reclamation manages flow on the Stanislaus and Lower San Joaquin rivers, temperatures have also been unaffected. Water temperatures in the Stanislaus River are largely driven by the temperature of water released from New Melones Dam and any warming in Tulloch Reservoir and Goodwin Reservoir. Downstream air temperatures warm or cool water between Goodwin Dam and Orange Blossom Bridge depending on the season, and this warming or cooling is buffered at higher flows due to increased thermal mass. Further downstream, in the Lower San Joaquin River, water temperatures at Vernalis are mostly unsuitable for rearing in late spring, especially in drier years. Water temperatures at Vernalis are likely to be stressful to out-migrating CCV steelhead, May through September, at times serving as a barrier to migration. According to (Deas 2004), in April, May, and particularly June, San Joaquin River water temperatures can reach stressful levels and may be limiting to young salmonids.

Delta

CVP and SWP facilities in the Delta provide for delivery of water supply to areas within and immediately adjacent to the Delta, and to regions south of the Delta.

The major CVP features are the Delta Cross Channel, Contra Costa Canal and Rock Slough Intake facilities, Jones Pumping Plant, and Tracy Fish Collection Facility. The main SWP Delta features are Suisun Marsh facilities, Banks Pumping Plant, CCF, Skinner Fish Facility, and Barker Slough Pumping Plant. These facilities and their operation under the proposed action are described in subsequent sections.

According to Reclamation (2023-2024), the following non-discretionary actions and requirements apply to their operations:

- Major facilities within the CVP's Bay-Delta Division include the physical presence of the Delta Cross Channel, the Contra Costa Canal and Pumping Plants, Contra Loma Dam, Martinez Dam, the C.W. "Bill" Jones Pumping Plant (formerly Tracy Pumping Plant), the Tracy Fish Collection Facility, the Delta-Mendota Canal, and the Delta-Mendota Canal/California Aqueduct Intertie Pumping Plant. Major SWP facilities within the Delta include the Suisun Marsh Salinity Control Gates, Harvey O. Banks Pumping Plant, Clifton Court Forebay, and the John E. Skinner Delta Fish Protective Facility.

There are two primary categories of effects in the South Delta due to water export: (1) salvage and entrainment at the South Delta export facilities, and (2) water-project-related changes to South Delta hydrodynamics that may reduce the suitability of the South Delta for supporting successful rearing or migration of salmonids and sturgeon from increased predation probability and exposure to poor water quality conditions. Key water-project-related drivers of South Delta hydrodynamics are Vernalis inflow, CVP and SWP exports from the South Delta export facilities and construction of agricultural barriers; these drivers interact with tidal influences over much of the central and southern Delta. In day-to-day operations, these drivers are often correlated with one another (for example, exports tend to be higher at higher San Joaquin River inflows) and regulatory constraints on multiple drivers may simultaneously be in effect. The Salmonid Scoping Team (SST), a technical team associated with the Collaborative Adaptive Management

Team (CAMT) process, evaluated how the relative influence of these drivers on hydrodynamic conditions varied temporally and spatially throughout the South Delta (Salmonid Scoping Team 2017b), Appendix B: Effects of Water Project Operations on Delta Hydrodynamics). In order to describe the driver-specific effects on South Delta hydrodynamics which are relevant to the types of operations anticipated in the proposed action, highlights of that report are provided below. The Delta flow regime can have effects on a wide range of factors such as productivity, food webs, invasive species, and management actions related to CVP and SWP operations, which are just a few of many interacting drivers (Monismith et al. 2014, Delta Independent Science Board 2015).

Export effects in the South Delta adversely impact hydrodynamic conditions in the South Delta and are expected to reduce the probability that juvenile salmonids in the South Delta will successfully migrate out past Chipps Island, either via entrainment or mortality at the export facilities, or by changes to migration rates or routes that increase residence time of juvenile salmonids in the South Delta and thus increase exposure time to agents of mortality such as predators, contaminants, and impaired water quality parameters (such as dissolved oxygen or water temperature). Effects of exports depend on location within the South Delta.

Operations of the CVP and SWP prior to the NMFS' 2009 Opinion reduced survival of juvenile salmonids out-migrating through the Delta. Prior to the protections established by the NMFS' 2009 Opinion (National Marine Fisheries Service 2009a), mortality of SR winter-run Chinook salmon juveniles entering the interior of the Delta (through the Delta Cross Channel or Georgiana Slough) was estimated to be approximately 66 percent, with a range of 35 to 90 percent mortality (Burau et al. 2007, Perry and Skalski 2008, Vogel 2008). Studies indicate overall mortality through the Delta for late fall-run Chinook salmon releases near Sacramento from 2006 through 2010 ranged from 46 to 83 percent (Perry et al. 2016). The available studies are consistent in that mortality is considerably higher through the Central and South Delta than if the juveniles stayed within the mainstem Sacramento River. Current operations of the CVP and SWP consistent with the NMFS 2009' Opinion requires specific actions aimed to improve freshwater and estuarine survival by managing Delta Cross Channel gate and export facility operations.

The operation of the Delta Cross Channel gates can negatively impact migration of sDPS green sturgeon as well by providing false migration cues for juvenile and adult sturgeon to move from the Lower Sacramento River to the Central Delta rather than their intended destination of the western Delta and San Francisco Bay (National Marine Fisheries Service 2018e). Green sturgeon are also vulnerable to entrainment at the unscreened diversions of the Sacramento River and Delta; flow and pipe configuration affects entrainment rates (Mussen et al. 2014a, Poletto et al. 2014). Efforts to salvage sDPS green sturgeon at the CVP and SWP have been conducted for decades, and the number of sDPS green sturgeon observed in these facilities is typically low with a few individuals per year (National Marine Fisheries Service 2018e).

Much uncertainty remains about how reach-scale hydrodynamic effects link to salmonid migration behavior in the South Delta. More data are available on both through-Delta survival and reach-scale survival for Chinook salmon and CCV steelhead. Recent reports summarize select data relevant to water-project-related effects on juvenile salmonid migration and survival in the South Delta (see in particular Appendices D and E of Volume 1, Salmonid Scoping Team 2017a). These reports summarize the latest information on salmonid behavior and survival in the

South Delta in the context of water project operations and so offer relevant information. Some overarching findings, summarized in Volume 1, are:

- Spatial variability in the relative influence of Delta inflow and exports on hydrodynamic conditions means that any given set of operational conditions may differentially affect fish routing and survival in different Delta regions
- Gates and barriers influence fish routing away from specific migration corridors
- The relationship between San Joaquin River inflow and survival is variable and depends on barrier status and region of the Delta
- Juvenile salmonid migration rates tend to be higher in the riverine reaches and lower in the tidal reaches
- The extent to which management actions such as reduced Old and Middle River reverse flows, ratio of San Joaquin River inflow to exports, and ratio of exports to Delta inflow affect through-Delta survival is uncertain
- Uncertainty in the relationships between South Delta hydrodynamics and through-Delta survival may be caused by the concurrent and confounding influence of correlated variables, overall low survival, and low power to detect differences

The first four findings highlight that effects on routing and survival differ across the Delta and are sensitive to inflow and barrier status.

Entrainment of juvenile SR winter-run Chinook salmon, CV spring-run Chinook salmon, and CCV steelhead at the South Delta export facilities may result in mortality. "Loss" is a term used to refer to the estimated number of fish that experience mortality within the export facilities and is estimated based on the number of salvaged fish (fish observed within the fish collection facilities at the export facilities) and factors related to facility efficiency and handling. Percentages refer to the percent of fish reaching a specific stage in the salvage process that are assumed to experience mortality during that stage. For example, the 75 percent loss associated with prescreen loss at the SWP means that 75 percent of the fish entering Clifton Court Forebay at the radial gates are assumed to die before reaching the primary louvers at the Skinner Fish Protective Facility. Of those fish that do reach the louvers, another 25 percent are lost, and so on. The total loss percentages represent the overall percent loss across all stages, that is, the percent of all fish entering the facility that die somewhere during the salvage process. Loss percentages at the SWP and CVP South Delta export facilities are described below.

- SWP: (1) Prescreen loss (from Clifton Court Forebay radial gates to primary louvers at the Skinner Fish Protective Facility): 75 percent loss; (2) Louver efficiency: 25 percent loss; (3) Collection, handling, trucking, and release: 2 percent loss; (4) Post release: 10 percent loss; and (5) Total loss (combination of the above): 83.5 percent
- CVP: (1) Prescreen loss (in front of trash racks and primary louvers): 15 percent loss; (2) Louver efficiency: 53.2 percent loss; (3) Collection, handling, trucking, and release: 2 percent loss; (4) Post release: 10 percent loss; and (5) Total loss (combination of the above): 35.1 percent

In 2022, CAMT sought to update the 2017 SST Report by formulating five charge questions related to salmon survival, routing, and behavior through the South Delta. A Salmon Technical Working Group (STWG) was formed and charged with answering these questions through a

review of recent research. The STWG invited researchers to share their findings with the group, then synthesized the information conveyed within the context of answering the five questions. The STWG's review considered analyses of survival and behavior of acoustically tagged, hatchery-origin juvenile salmon and steelhead released into the San Joaquin River upstream of the Delta for the years currently available (2008–2017, Salmon Technical Working Group 2024).

The STWG focused on results published since the SST report was issued in 2017 related to: (1) reach-specific survival based on complete sets of acoustic telemetry data for CCV steelhead and fall-run Chinook salmon; (2) the behavior of CCV steelhead and fall-run Chinook salmon at distributary junctions; and (3) new information on CV spring-run Chinook salmon survival through the Delta and behavior at the Head of Old River junction.

Many of the key findings from the 2017 SST report have been affirmed. However, the STWG acknowledged that in order to develop more definitive conclusions regarding export effects, a different study approach would be required. For example, to date the analyses have largely centered on the use of single-variate analyses to address complex issues with confounding variables. The focus has been on biological responses of routing and survival over generally large reaches (e.g., what is the effect of exports on through-Delta survival?). While this approach is useful, there is a potential lack of congruence in the results presented in the STWG report. Namely, few export effects have been documented, yet overall survival remains low. This raises questions as to whether the conceptual model underlying current analytical models needs to be updated. In addition, the STWG hypothesizes there are other factors contributing to poor survival of juvenile salmonids in the Delta (e.g., habitat degradation, proliferation of non-native fish species, poor water quality, lower inflows, higher water temperature, etc.), only some of which are directly or indirectly related to exports.

Though considerable uncertainties remain, the lack of a detectable trend between exports and survival of San Joaquin River-origin salmonids challenges the current conceptual model that assumes a strong negative relationship between the two. To move beyond the current impasse in learning, the STWG recommends refinement of the conceptual model around the effects of exports. Consideration of other factors impacting survival and shifting the overall focus towards improving survival at various scales by identifying, recreating, testing, and building upon the conditions where and when salmonids have had success (i.e., higher survival).

6.2. Impacts of Dams and Other Passage Impediments

The construction of dams and other structures around the Central Valley has blocked anadromous salmonids and sturgeon from most of their historic spawning and initial rearing habitat, eradicating most historic populations of SR winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon. Between 72 to 90 percent of the original Chinook salmon spawning and holding habitat in the Central Valley drainage is no longer accessible due to dam construction (Figure 32), (Yoshiyama et al. 2001, Cummins et al. 2008). Sacramento River winter-run Chinook salmon lost three of its four historical spawning populations with the construction of Keswick and Shasta dams. Perhaps 15 of the 18 or 19 historical populations of CV spring-run Chinook salmon are extirpated, with their entire historical spawning habitats upstream from impassable dams (Lindley et al. 2007). Currently,

impassable dams block access to 80 percent of historically available habitat and block access to all historical spawning habitat for about 38 percent of the historical populations of CCV steelhead (Lindley et al. 2006). Modeling by Mora et al. (2009) indicates about 9 percent of historic sDPS green sturgeon habitat has been blocked by dams. Impassable barriers are considered to be the main threat to sDPS green sturgeon as migration corridors are blocked and migration cues (water flow) are altered (National Marine Fisheries Service 2018e). The existence of these impassable barriers has significant adverse effects on species in the past, present, and future.

Prior to 2012, the seasonal closure of Red Bluff Diversion Dam limited sDPS green sturgeon spawning to habitats that were likely unsuitable for egg incubation in some years. With the permanent decommissioning of Red Bluff Diversion Dam gates, sDPS green sturgeon presumably have access to suitable spawning and incubation areas on the Sacramento River under all conditions (e.g., droughts). ACID dam, approximately 5 miles below Keswick Dam (river mile 302), remains a potential passage barrier to spawning sDPS green sturgeon on the Sacramento River. The percentage of the sDPS green sturgeon spawning run that would utilize the uppermost 5 miles of the Sacramento River between ACID dam and Keswick Dam is unknown, but is currently estimated to be small based on the lack of acoustic tag detections in this reach.

The flood control weirs of the Yolo and Sutter bypasses can serve as barriers to salmon, steelhead, and green sturgeon migration during high water events (Thomas et al. 2013). During some high flow events, these fish enter the Yolo and Sutter bypasses and become stranded when the water recedes. In some cases, adult sturgeon remain stranded in small isolated bypass ponds through the summer or fall, making them vulnerable to poaching and other sources of mortality. In 2011, 24 sDPS green sturgeon individuals were rescued from the Yolo and Sutter bypasses (Thomas et al. 2013). Since relocation efforts cannot prevent all mortality associated with stranding, and the loss of even a few adult fish periodically should be avoided, it is important to construct structures at these weirs that allow volitional passage of upstream migrating sDPS green sturgeon.

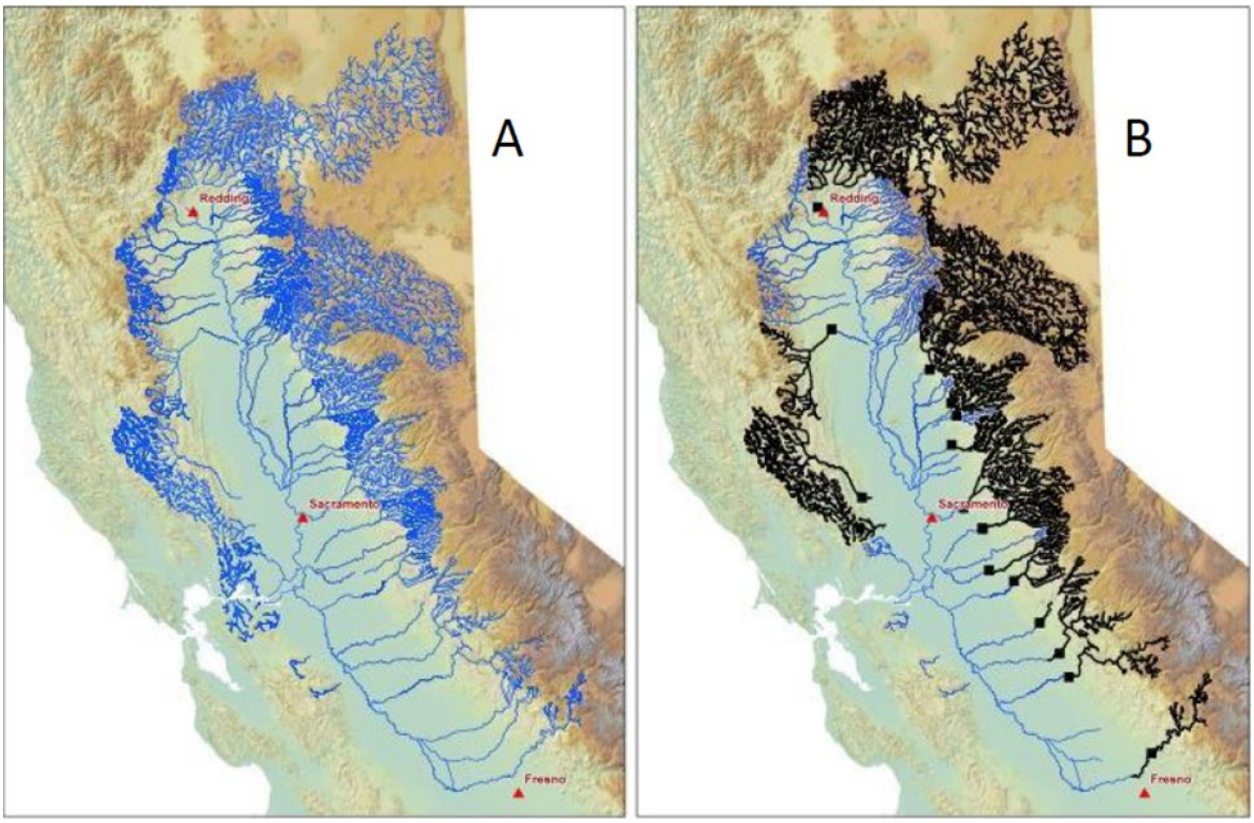


Figure 32. Historical habitat accessible to salmonids (A, in blue) and lost upstream habitat (B, in black) from construction of impassable dams (black squares). Remaining anadromous salmon habitat is confined to the valley floor (B, in blue).

6.3. Levees

The construction of levees throughout the Sacramento and San Joaquin river watersheds has resulted in a landscape in which less than 5 percent of the native wetland, riparian, and floodplain habitats remain (Whipple et al. 2012) and the presence of existing levees generally is in the Environmental Baseline. Ninety-three percent of historic floodplain rearing habitat is no longer accessible due to levee construction (Figure 33, Herbold et al. 2018). Those dynamic shallow water habitats that historically provided food-rich areas for rearing salmonids have been almost entirely replaced by urban and agricultural landscapes (Herbold et al. 2018). Given that juvenile salmon grow faster when they have access to inundated floodplain habitat than in adjacent river channels (Sommer et al. 2001b, Jeffres et al. 2008), it is likely that overall salmonid productivity has been diminished with the majority of Sacramento and San Joaquin rivers now confined by levees in all but the wettest years.

Central Valley salmonids evolved with access to a diverse suite of shallow water habitats, promoting resilience against a variable climate. Now adaptations to earlier conditions are mismatched with the current simplified river systems. Important sources of habitat diversity for juvenile salmonids in the current system are Yolo and Sutter flood bypasses, where salmonids can access food rich floodplain habitat under high flows. Still, with so little freshwater habitat now available in the Central Valley, habitat heterogeneity has decreased, and we expect

salmonid population diversity and resilience has decreased (Figure 34) and vulnerability to climate variability and change has increased since the pre-dam period (Herbold et al. 2018).

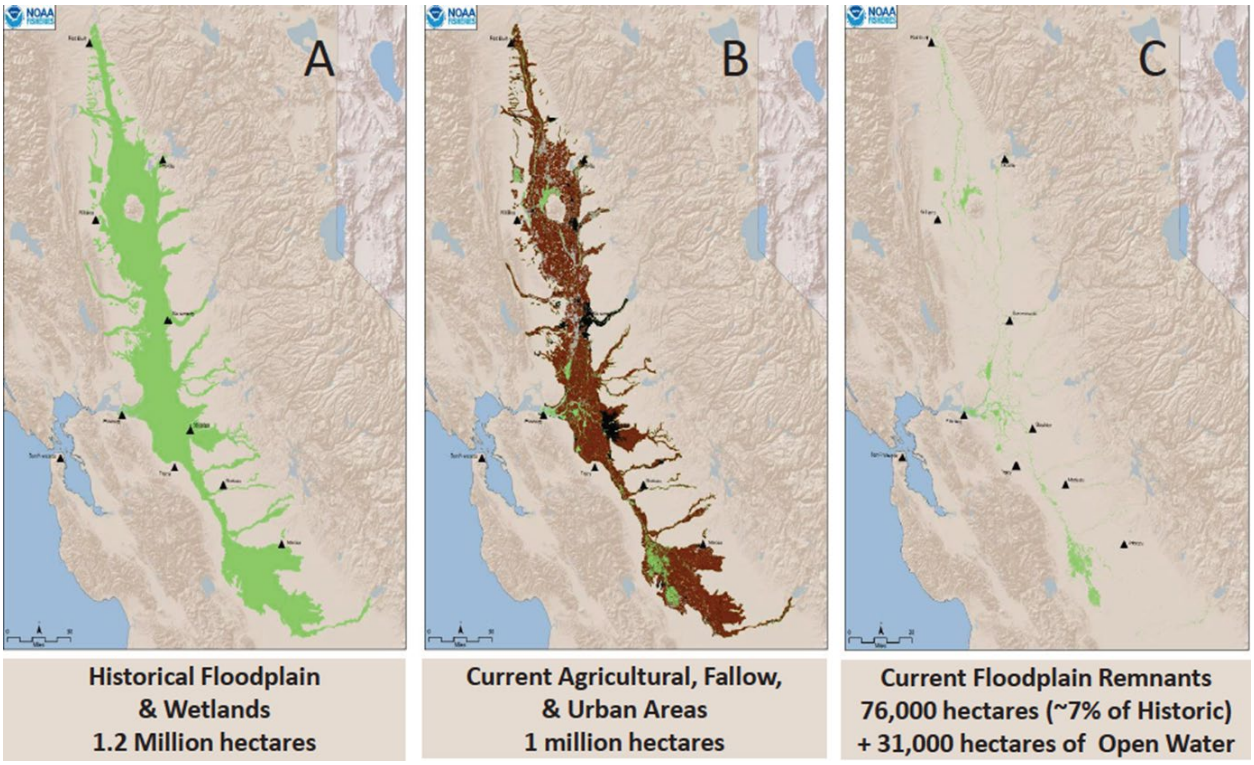


Figure 33. (A) Historical floodplain and Delta wetlands habitat; (B) remnant floodplain and wetland habitat currently in agricultural lands, fallow lands, or urban areas; and (C) floodplain and wetland remnants.

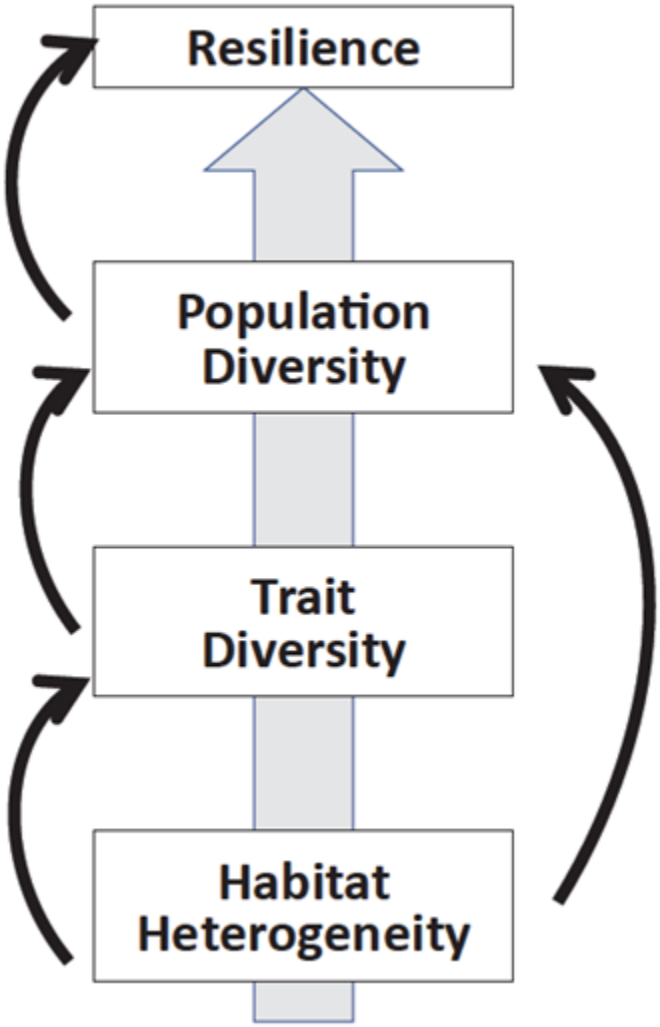


Figure 34. Conceptual model of how habitat heterogeneity creates trait and phenotypic diversity to promote population resilience.

Source: (Herbold et al. 2018)

6.4. Gold Mining

The first major anthropogenic impact on the Central Valley watersheds came from hydraulic mining in the years shortly after the California gold rush began in 1848. By 1859, an estimated 5,000 miles of mining flumes and canals diverted streams used by salmonids and sturgeon for spawning and nursery habitat. Habitat alteration and destruction also resulted from the use of hydraulic cannons and from hydraulic and gravel mining, which leveled hillsides and sluiced an estimated 1.5 billion cubic yards of debris into the streams and rivers of the Central Valley (Lufkin 1991). Mining practices profoundly altered landscape forms and processes; streams were dammed, diverted or drained; soil and vegetation was stripped over large areas; piles of coarse mine tailings reduced floodplain inundation; and excessive sediment loading massively aggraded and armored stream channels. Many of these impacts persist today, with severe and enduring

effects on critical habitat for salmon species (National Marine Fisheries Service 2014b) and for sDPS green sturgeon (National Marine Fisheries Service 2018e).

6.5. Climate Change

One major factor affecting the range-wide status of the threatened and endangered anadromous fish in the Central Valley and aquatic habitat at large is climate change.

The globally-averaged combined land and ocean surface temperature data, as calculated by a linear trend, show a warming of approximately 1°C (1.8°F) from 1901 through 2016 (Jay et al. 2018). The *IPCC Special Report on the Impacts of Global Warming* (IPCC 2023) noted that human-induced warming reached a global surface temperature of 1.1°C (2.0°F) above pre-industrial levels by 2020, and global surface temperature has increased faster since 1970 than in any other 50-year period over at least the last 2000 years.

Annual average temperatures have increased by 1.8°C (3.2°F) across the contiguous United States since the beginning of the 20th century, with Alaska warming faster than any other state and twice as fast as the global average since the mid-20th century (Jay et al. 2018). Global warming has led to more frequent heat waves in most land regions and an increase in the frequency and duration of marine heatwaves (IPCC 2023). Average global warming up to 1.5°C (2.7°F) as compared to pre-industrial levels is expected to lead to regional changes in extreme temperatures and increases in the frequency and intensity of precipitation and drought (IPCC 2023).

From 2012 to 2016, California experienced the most extreme drought since instrumental records began in 1895. A growing body of evidence suggests that climate change has increased the likelihood of extreme droughts in California (California Department of Water Resources 2018a). California experienced well below average precipitation during the 2012-2016 drought, as well as record high surface air temperatures in 2014 and 2015, and record low snowpack in 2015 (Williams et al. 2016). Paleoclimate reconstructions suggest the 2012-2016 drought was the most extreme in the past 500 to 1000 years (Williams et al. 2016, Williams et al. 2020, Williams et al. 2022). Anomalously high surface temperatures substantially amplified annual water deficits during 2012-2016. California entered another period of drought in 2020. These drought periods are now likely part of a larger drought event (Williams et al. 2022). This recent long-term drought, as well as the increased incidence and magnitude of wildfires in California, have likely been exacerbated by climate change (Diffenbaugh et al. 2015, Williams et al. 2019, Williams et al. 2020, Williams et al. 2022).

Warmer temperatures associated with climate change reduce snowpack and alter the seasonality and volume of seasonal hydrograph patterns (Cohen et al. 2000). Central California has shown trends toward warmer winters since the 1940s (Dettinger and Cayan 1995). An altered seasonality results in runoff events occurring earlier in the year due to a shift in precipitation falling as rain rather than snow (Roos 1991, Dettinger et al. 2004). Specifically, the Sacramento river basin annual runoff amount for April to July has been decreasing since about 1950 (Roos 1987, Roos 1991). Increased temperatures influence the timing and magnitude patterns of the hydrograph and strain the ability of reservoir water managers to provide cold water releases for salmonids.

The magnitude of snowpack reductions is subject to annual variability in precipitation and air temperature. Large spring snow water equivalent percentage changes late in the snow season are due to a variety of factors including reduction in winter precipitation and temperature increases that rapidly melt spring snowpack (Vanrheenen et al. 2004). Factors modeled by Vanrheenen et al. (2004) show that the melt season shifts to earlier in the year, leading to a large percent reduction of spring snow water equivalent (up to 100 percent in shallow snowpack areas). Additionally, an air temperature increase of 2.1°C (3.8°F) is expected to result in a loss of about half of the average April snowpack storage (Vanrheenen et al. 2004). The decrease in spring snow water equivalent (as a percentage) would be greatest in the region of the Sacramento River watershed, at the north end of the Central Valley, where snowpack is shallower than in the San Joaquin River watersheds to the south.

Warming attributed to climate change is expected to affect Central Valley anadromous salmonids and sDPS green sturgeon more than it already has. Because the Central Valley salmon, steelhead, and green sturgeon runs are restricted to low elevations as a result of impassable dams, if the climate warms by 5°C (9°F), it is questionable whether any Central Valley Chinook salmon and sDPS green sturgeon populations can persist (Williams 2006, National Marine Fisheries Service 2018e). Based on an analysis of an ensemble of climate models and emission scenarios and a reference temperature from 1951 to 1980, the most plausible projection for warming over Northern California is 2.5°C (4.5°F) by 2050 and 5°C by 2100, with a modest decrease in precipitation (Dettinger 2005). Chinook salmon in the Central Valley are at the southern limit of their range, and warming will shorten the period in which the low elevation habitats can support salmonid life stages. Projected 33 percent salinity increases in the Sacramento river basin in the 21st century due to climate change may result in declining habitat quality and food web productivity; climate change will alter the salinity and prey base in sDPS green sturgeon juvenile rearing habitat and adult migration corridors (CH2M HILL 2014, National Marine Fisheries Service 2018e).

There is also a high threat posed by altered water temperatures due to climate change. In the Sacramento river basin, climate change models predict increased air temperatures in the Central Valley and surrounding mountains (Ficklin et al. 2012), altered precipitation patterns with a higher frequency of dry years, reduced spring snowpack, and reduced spring flows (Knowles and Cayan 2002, CH2M HILL 2014). Water temperatures in the Sacramento river basin could also increase (CH2M HILL 2014). A warming climate with continued changes in precipitation patterns may influence reservoir operations and thus influence water temperature and flow that fish experience in the Central Valley.

Growth and survival rates of salmon in the California Current off the Pacific Northwest can be linked to fluctuations in ocean conditions related to Pacific Decadal Oscillation and the El Nino-Southern Oscillation conditions and events, as well as the recent northeast Pacific marine warming phenomenon (also known as “the blob”; Peterson et al. 2006, Wells et al. 2008). Evidence exists that suggests early marine survival for juvenile salmon is a critical phase in their survival and development into adults.

In marine environments, ecosystems and habitats important to juvenile and adult salmonids are likely to experience changes in temperatures, circulation, water chemistry, and food supplies (Feely et al. 2004, Brewer and Barry 2008, Osgood 2008, Turley 2008, Abdul-Aziz et al. 2011,

Doney et al. 2012). Some of these changes, including an increased incidence of marine heat waves, are likely already occurring, and are expected to increase (Frölicher et al. 2018).

The correlation between various environmental indices that track ocean conditions and salmon productivity in the Pacific Ocean, both on a broad and a local scale, provides an indication of the role they play in salmon survival in the ocean. Moreover, when discussing the potential extinctions of salmon populations, climate patterns would not likely be the sole cause, but could certainly increase the risk of extinction when combined with other factors, especially in ecosystems under stress from humans (Francis and Mantua 2003).

6.6. Invasive Species/Food Web Disruption

During the development of the Recovery Plan for Central Valley Chinook Salmon and Steelhead (National Marine Fisheries Service 2014b), invasive species/food web disruption was identified as a primary stressor affecting the recovery of the species. This threat primarily affects the juvenile rearing and out-migration life stage of these species through the Delta and bays.

Invasive species include both plants and animals, most of which have been introduced to the Delta unintentionally through ship ballast water. However, some species have been introduced intentionally by resource agencies for sportfishing or forage. Invasive aquatic plants have become established in many areas of the Delta. Establishment of invasive aquatic plants can harm or kill native aquatic species because they form dense mats that block sunlight and deplete oxygen supplies. Most of these aquatic weeds were introduced to the Delta unintentionally and include water hyacinth (*Eichhornia crassipes*), hydrilla (*Hydrilla verticillata*), and egeria (*Egeria densa*). Within the Delta, the construction of levees and the conversion of adjacent riparian communities to other land uses have substantially changed the ecosystem. These changes have stressed native aquatic flora and fauna allowing infestation of invasive aquatic weeds. Invasive weeds flourish in the disturbed environment and may reduce food web productivity, potentially harming fish and wildlife (CALFED Bay-Delta Program 2000).

The majority of clams, worms, and bottom-dwelling invertebrates currently inhabiting the Delta are non-native species. Non-native species also comprise an increasing proportion of the zooplankton and fish communities in the Bay-Delta system. It is estimated that a new non-native species is identified in the Bay-Delta every 15 weeks (CALFED Bay-Delta Program 2000). Many fish known to prey on juvenile anadromous salmonids were introduced by resource agencies to provide sportfishing. These fish include striped bass, American shad (*Alosa sapidissima*), and largemouth bass (*Micropterus salmoides*). Although introductions have increased diversity in the Bay-Delta system, this increase in diversity has been at the expense of native species, many of which have declined precipitously or become extinct through predation and competition for resources (CALFED Bay-Delta Program 2000). At the same time, many non-native species are performing vital ecological functions such as serving as primary consumers of organic matter or as a food source for native fish and other wildlife populations (CALFED Bay-Delta Program 2000).

One of the most important habitat attributes of the riverbed to listed anadromous fish species in the action area is the production of food resources for rearing and migrating juveniles, such as drifting and benthic invertebrates, forage fish, and fish eggs. Benthic invertebrates, such as

oligochaetes and chironomids (dipterans), are the predominant juvenile salmonid and sDPS green sturgeon food items produced in the silty and sandy substrates of the action area. Although specific information on food resources for sDPS green sturgeon within freshwater riverine systems is lacking, they are presumed to be generalists and opportunists that feed on similar prey to other sturgeons (Israel and Klimley 2008), such as the population of white sturgeon (*Acipenser transmontanus*) present and coexisting with sDPS green sturgeon in the Sacramento river basin. Seasonally abundant drifting and benthic invertebrates have been shown to be the major food items of white sturgeon in the lower Columbia River (Muir et al. 2000). As sturgeons grow, they begin to feed on oligochaetes, amphipods, smaller fish, and fish eggs as represented in the diets of white sturgeon (Muir et al. 2000).

Historically, the San Joaquin River has been an important source of nutrients to the Delta. Most of the San Joaquin River is now being diverted from the South Delta by CVP and SWP operations. The resultant loss in nutrients has likely contributed to an overall decrease in fertility of the Delta, limiting its ability to produce food (National Marine Fisheries Service 1997). Additionally, pumping operations may result in a loss of zooplankton, reducing their abundance in the Delta. Poor food supply may limit the rearing success of SR winter-run Chinook salmon. Extensive areas of the Delta are below mean high tide, but because of levees and flap gates installed throughout the Delta, these areas are no longer subject to tidal action. This effectively reduces the volume of water subject to tidal mixing and the size of the Delta floodplain. Reduced residence time of Delta water and associated nutrients restricts the development of food web organisms (CALFED Bay-Delta Program 2000).

The multi-agency SAIL synthesis teams (Windell et al. 2017) found predation by non-native species affected SR winter-run Chinook salmon (but also CV spring-run Chinook salmon and CCV steelhead) egg survival, timing, and condition and juvenile survival, residence time/migration, and growth.

6.7. Loss of Riparian Habitat and Instream Cover

The Recovery Plan for Central Valley Chinook Salmon and Steelhead (National Marine Fisheries Service 2014b) identified loss of riparian habitat and instream cover as a primary stressor affecting the recovery of the species. This threat primarily affects the juvenile rearing and out-migration life stage of these species, from the upper reaches of their watershed of origin through the Delta. Effects of the action that contribute to the loss of riparian habitat and instream cover are likely to result in a probable change in fitness of: reduced growth and/or reduced survival probability.

Loss of riparian habitat and instream cover refers to the process by which access to riparian habitat and instream cover is lost either by the construction of river features (i.e., levees or flood control structures) or by river channelization due to the geological formation and controlled flow regimes that result in disconnection of the river from its historic floodplain. Construction of river features involves rip-rapping the river bank and removing vegetation along the bank and upper levees which removes most instream and overhead cover in nearshore areas. This has negative effects on riparian habitat due to the river's inability to naturally recruit riparian species seedlings as well as woody debris to deposit elsewhere. Woody debris and overhanging vegetation within shaded riverine aquatic habitat provide escape cover for juvenile salmonids

from predators as well as thermal refugia. Aquatic invertebrates are dependent on the organic material provided by a healthy riparian habitat, and many terrestrial invertebrates also depend on this habitat. Studies by the CDFG demonstrated that a significant portion of the juvenile Chinook salmon diet is composed of terrestrial insects, particularly aphids, which are dependent on riparian habitat (National Marine Fisheries Service 1997).

The multi-agency SAIL synthesis teams also identified the relevant pathways by which loss of riparian habitat and instream cover is likely to affect SR winter-run Chinook salmon (and similar conceptual models can apply to CV spring-run Chinook salmon and CCV steelhead), as well as how it is likely to interact with other stressors. Specifically, (Windell et al. 2017) focused on the growth and condition of juveniles as being affected by access to riparian habitats. Habitats that provide refuge from high water velocity or predators, without depleting food supply, function to increase growth rates by reducing energy demand to obtain a given food supply. Growth rate may then influence migration timing and success, where a higher growth rate is associated with earlier smoltification and faster downstream migration (Beckman et al. 2007). However, the inability of a juvenile in a particular habitat to supply its metabolic demand and achieve some threshold growth rate may also serve as a strong cue to leave that habitat and migrate downstream, and a satisfactory food supply may induce a juvenile to remain in the habitat for a longer duration of time to rear.

6.8. Loss of Natural River Morphology and Function

The Recovery Plan for Central Valley Chinook Salmon and Steelhead (National Marine Fisheries Service 2014b) identified loss of natural river morphology and function as a primary stressor affecting the recovery of the species. This threat primarily affects the juvenile rearing and out-migration life stage of these species from the upper reaches of their watershed of origin through the Delta.

Loss of natural river morphology and function is the result of river channelization and confinement, which leads to a decrease in riverine habitat complexity, and thus, a decrease in the quantity and quality of juvenile rearing habitat. Additionally, this primary stressor category includes the effect that dams have on the aquatic invertebrate species composition and distribution, which may have an effect on the quality and quantity of food resources available to juvenile salmonids. For example, in a natural river system without one or more large dams, there is an upstream source of lotic aquatic invertebrate species available to juvenile salmonids, whereas on a river with a large terminal dam, the upstream drift of food resources to juvenile salmonids is drastically altered.

The multi-agency SAIL synthesis teams also identified the relevant pathways by which loss of natural river morphology and function is likely to SR winter-run Chinook salmon (and similar conceptual models can apply to CV spring-run Chinook salmon and CCV steelhead) as well as how it is likely to interact with other stressors. Specifically, (Windell et al. 2017) focused the impact of channelized, leveed, and rip-rapped reaches potentially having low habitat complexity, low abundance of food organisms, and offering little protection from predators—factors which juveniles are dependent on for growth and successful survival.

Water depth modification caused by non-point source sediment was ranked in the Recovery Plan as a high threat to sDPS green sturgeon adults within the Sacramento river basin and a medium threat to other life stages in the Sacramento river basin (National Marine Fisheries Service 2018e). Impoundments and mitigation and restoration efforts were also considered as contributing to the water depth modification threat to all life stages in the Sacramento river basin. Non-point source sediment includes runoff from urban areas, agriculture, forests, irrigated lands, landfills, livestock, mining operations, nurseries, orchards, etc. Removal of riparian vegetation results in increased erosion and input of fine grain material into the water. Sediment from these sources can be deposited in pools. The sDPS of green sturgeon require deep pools for spawning and holding in the Sacramento river basin. Large impoundments (e.g., Oroville and Shasta reservoirs) that reduce the frequency of high flow events may limit pool scouring and result in a reduction of pool depth. Survival and development of early life stages within the Sacramento river basin may also be impacted by non-point source sediments through altered turbidity and substrate composition. At the time that the Recovery Team conducted its assessment, the High ranking for adults was attributed, in part, to the impact of water depth modification on the quantity and habitat quality of deep pools. The work of Mora (2016) indicates 50 to 125 areas with greater than 5-meter depth available on the mainstem Sacramento River depending upon the year. It is uncertain as to whether all of these pools supply sufficient habitat for spawning and holding in terms of depth and substrate.

6.9. Loss of Floodplain Habitats

Loss of floodplain habitat and loss of wetland function have been identified as primary stressors affecting the recovery of Central Valley salmonid species (National Marine Fisheries Service 2014b) and sDPS green sturgeon (National Marine Fisheries Service 2018e). This threat primarily affects the juvenile rearing and out-migration life stage of these species from the upper reaches of their watershed of origin through the Delta.

Although riverine floodplains support high levels of biodiversity and productivity, they are also among the most converted and threatened ecosystems globally (Opperman et al. 2010). In California, more than 90 percent of wetlands have been lost since the mid-1800s (Garone 2011, Hanak et al. 2011). Loss of floodplain habitat within the Central Valley is a result of controlled flows and decreases in peak flows which have reduced the frequency of floodplain inundation resulting in a separation of the river channel from its natural floodplain. Channelizing the rivers and Delta has also resulted in a loss of river connectivity with the floodplains that otherwise provide woody debris and gravels that aid in establishing a diverse riverine habitat and that provide juvenile salmonid rearing habitat.

The importance of connectivity for juvenile Chinook salmon to floodplain rearing habitat has been observed in several river systems. Research on the Yolo Bypass, the primary floodplain on the Lower Sacramento River, indicates that floodplains are key juvenile rearing habitats supporting significantly higher drift invertebrate consumption and therefore faster growth rates (Sommer et al. 2001a, Katz et al. 2017). Otolith microstructure studies near the City of Chico recorded increased fall-run Chinook salmon growth, higher prey densities, and warmer water temperatures in off-channel ponds and non-natal seasonal tributaries compared to the main-channel Sacramento River (Limm and Marchetti 2009). Research of juvenile Chinook salmon on

the Cosumnes River noted that ephemeral floodplain habitats supported higher growth rates for juvenile Chinook salmon than more permanent habitats in either the floodplain or river (Jeffres et al. 2008). This growth is important to first-year and estuarine survival, factors which may be key influences of a Chinook cohort's success (Kareiva et al. 2000).

As with other stressors, the SAIL synthesis teams referenced the relevant pathways by which loss of floodplain habitat could SR winter-run Chinook salmon (and similar conceptual models can apply to CV spring-run Chinook salmon and CCV steelhead) as well as how it may interact with other stressors. However, instead of describing the negative effects caused by a loss of floodplain habitat*,* (Windell et al. 2017) examined the benefit of juvenile rearing on floodplains as it relates to survival, residence time and migration, and fish condition. The SAIL report notes the interaction with higher flows that activate accessible floodplains and secondary channels, which thereby expand the availability of low-velocity refuge habitat. The SAIL report also identifies inundated floodplains in the Central Valley as being particularly successful habitat for fish growth because it provides optimum water temperature, lower water velocity, higher food quality and density, and reduced predator and competitor density relative to the main channel (Windell et al. 2017).

6.10. Spawning Habitat Availability

The Recovery Plan for Central Valley Chinook Salmon and Steelhead (National Marine Fisheries Service 2014b) identified spawning habitat availability as a primary stressor affecting the recovery of the species. This threat primarily affects the spawning life stage of these species in the upper reaches of their watershed of origin. One of the greatest threats to sDPS green sturgeon is the loss of spawning habitat due to the construction of dams in the Sacramento River system. Dams have limited available spawning habitats and, along with water management practices, have changed the flow and temperature profiles of the three major rivers that could be utilized by sDPS green sturgeon for spawning (i.e., Sacramento, Feather, and Yuba rivers).

Generally, successful spawning for Chinook salmon occurs at water temperatures below 60°F (National Marine Fisheries Service 1997). Upper preferred water temperatures for spawning Chinook salmon range from about 55°F to 57°F (Reiser and Bjornn 1979). Chinook salmon spawn in riffles or runs with water velocities ranging from 0.5 to 6.2 feet per second (Healey 1991, Vogel and Marine 1991). Spawning depths can range from as little as a few inches to several feet (Moyle 2002). Preferred water depths appear to range from 0.8 to 3.3 feet (Allen and Hassler 1986, Moyle 2002). Substrate is an important component of Chinook salmon spawning habitat and generally includes a mixture of gravel and small cobbles (Moyle 2002). Preferred spawning substrate is composed mostly of gravels from 0.75 to 4.0 inches in diameter (National Marine Fisheries Service 1997). Spatially, the total area of viable salmonid spawning habitat has been significantly diminished. Physical features that are essential to the functionality of existing spawning habitat have also been degraded, such as the loss of spawning gravel and elevated water temperatures during summer months when spawning events occur (National Marine Fisheries Service 2014b). Degradation of these features is actively mitigated through real-time temperature and flow management at Shasta and Keswick dams (National Marine Fisheries Service 2009a) as well as gravel augmentation projects in the affected area, which have been occurring under a multi-year programmatic authority (National Marine Fisheries Service 2015c).

Current spawning of SR winter-run Chinook salmon is limited to the mainstem Sacramento River (Myers et al. 1998). Naturally-spawning populations of CV spring-run Chinook salmon currently are restricted to accessible reaches of the Upper Sacramento River, Antelope Creek, Battle Creek, Beegum Creek, Big Chico Creek, Butte Creek, Clear Creek, Deer Creek, Feather River, Mill Creek, and Yuba River (California Department of Fish and Game 1998).

6.11. Physical Habitat Alteration

The Recovery Plan for Central Valley Chinook Salmon and Steelhead (National Marine Fisheries Service 2014b) identified physical habitat alteration as a primary stressor affecting the recovery of the species. This threat primarily affects the spawning life stage of these species in the upper reaches of their watershed of origin.

Physical habitat alteration includes loss of natural river morphology and function. Flood control measures, regulated flow regimes, and river bank protection measures have all had a profound effect on riparian and instream habitat in the Lower Sacramento River. Levees constructed in this reach are built close to the river in order to increase streamflow, channelize the river to prevent natural meandering, and maximize the sediment carrying capacity of the river (National Marine Fisheries Service 1997). Additionally, nearshore aquatic areas have been deepened and sloped to a uniform gradient, such that variations in water depth, velocity, and direction of flow are replaced by consistent moderate to high velocities. Gravel sources from the banks of the river and floodplain have also been substantially reduced by levee and bank protection measures. Levee and bank protection measures restrict the meandering of the river, which would normally release gravel into the river through natural erosion and deposition processes.

Chinook salmon spawn in clean, loose gravel, in swift, relatively shallow riffles, or along the margins of deeper river reaches where suitable water temperatures, depths, and velocities favor redd construction and oxygenation of incubating eggs. The construction of dams and resultant controlled flows and extensive gravel mining affect spawning habitat. Chinook salmon require clean, loose gravel from 0.75 to 4.0 inches in diameter for successful spawning (National Marine Fisheries Service 1997). Juvenile Chinook salmon prefer slow and slack water velocities for rearing and the channelization of the river has removed most of this habitat type. The construction of dams in the Upper Sacramento River has eliminated the major source of suitable gravel recruitment to reaches of the river below Keswick Dam.

The threat of altered sediments to sDPS green sturgeon due to impoundments is high. The creation of upstream dams and impoundments can reduce sediment delivery to bays and estuaries. This can impact sDPS green sturgeon feeding habitat quality and quantity through changes in sediment deposition and composition and subsequent changes in prey resources or through changes in turbidity that could impact habitat use and predation by sight-predators.

6.12. Predation

The Recovery Plan for Central Valley Chinook Salmon and Steelhead (National Marine Fisheries Service 2014b), identified predation as a primary stressor affecting the recovery of the

species. This threat primarily affects the juvenile rearing and out-migration life stage of these species from the upper reaches of their watershed of origin through the Delta and bays.

Predator-prey interactions can be broken down into several fundamental steps between the prey and the predator. These steps include the rates of encounters between the predator and the prey, the rate at which the predator decides to pursue and attack the prey when detected, the rate at which the predator successfully captures the prey, and, ultimately, the rate at which the prey is consumed by the predator. Each one of these steps is influenced by biological and physical factors in the surrounding environment such as prey abundance, spatial and temporal overlap of prey with the predator, habitat complexity, turbidity, and behavioral, physiological, and morphological adaptations that facilitate (predator success) or inhibit (prey avoidance) the predation process (Grossman et al. 2013, Grossman 2016). Although predation is frequently the proximate cause of mortality, the ultimate cause of mortality is often related to alterations in the physical or biological parameters of the habitat that prey occupy that enhance the rate of predation. Because fish are highly adaptable, the response to habitat changes and quality are not always straightforward and linear and thus may not always be completely predictable, particularly on a shorter time scale. In general, though, habitat that is complex and offers a multitude of different niches provides for a more diverse biological community (Grossman et al. 2013, Grossman 2016). In a stable, undisturbed, functioning habitat, multiple species can occupy the same general area by each species occupying a particular ecological niche, thereby minimizing direct competition between species and having a balanced predator-prey interaction. This is particularly true in habitats where predators and prey have co-evolved with each other. This relationship does not exist or is compromised when habitat is altered or non-native species invade a new habitat, causing a loss of equilibrium among the species inhabiting it.

The Delta and Central Valley waterways are currently highly altered and disturbed habitats. In the aquatic ecosystems of the Central Valley and Delta waterways, widespread habitat alteration has occurred over the last 150 years. Predation is a threat to SR winter-run Chinook salmon, especially in the Delta where there are high densities of non-native fish (e.g., smallmouth bass [*Micropterus dolomieu*], largemouth bass, striped bass, catfish, and sculpin) that prey on out-migrating salmon. The presence of man-made structures in the environment that alter natural conditions likely also contributes to increased predation by altering the predator-prey dynamics often favoring predatory species. In the ocean, and even the Delta environment, salmon are common prey for harbor seals (*Phoca vitulina*) and sea lions. Most of the predation on juvenile Chinook salmon in the Delta likely occurs from introduced species such as striped bass, black crappie (*Pomoxis nigromaculatus*), white catfish (*Ameiurus catus*), largemouth bass, and bluegill (*Lepomis macrochirus*). Native Sacramento pikeminnow and steelhead also occur in the Delta and are known to prey on juvenile salmonids. Of these non-native predatory species, striped bass are likely the most important predators because: (1) the estimated abundance of striped bass in the Sacramento-San Joaquin system greater than 18 inches in length has ranged from about 600,000 to about 1,900,000 during the period between 1969 to 2005; (2) the total number of striped bass preying upon juvenile Chinook salmon in the system is greater than these estimated population sizes because striped bass smaller than 18 inches in length feed on juvenile Chinook salmon; (3) anecdotal information indicates that striped bass movements up the Sacramento River coincide with juvenile Chinook salmon emigration, resulting in a co-occupancy of habitat; and (4) striped bass are opportunistic feeders, and almost any fish or invertebrate occupying the same habitat eventually appears in their diet (Moyle 2002).

The multi-agency SAIL synthesis teams also identified the relevant pathways by which predation is likely to SR winter-run Chinook salmon (and similar conceptual models can apply to CV spring-run Chinook salmon and CCV steelhead) as well as how it is likely to interact with other stressors. Survival across all life stages and in all geographic regions can be affected by predation, particularly within the egg-to-fry emergence stage, rearing to out-migrating juveniles stage in the Upper and Middle Sacramento River and the Bay-Delta, and ocean juvenile to ocean adult stage (Windell et al. 2017).

Predation of juvenile salmonids and green sturgeon is thought to be a contributing factor to high mortality at this life stage (Hanson 2009, Vogel 2011, Michel et al. 2015). There have been significant alterations to aquatic habitat that are conducive to the success of non-native piscivorous fish such as creating a largely freshwater system out of the naturally estuarine, variable salinity Delta, riverbank armoring, and reduction of habitat complexity (Vogel 2011). The altered habitat and modified flow regimes have benefitted non-native striped bass, catfish, largemouth bass, and smallmouth bass, such that predation has been characterized as being, "…likely the highest source of mortality to anadromous fish in the Delta" (Vogel 2011). The 2009 RPA (RPA Action IV.4.2(2)(a)) required DWR to implement predator control methods within Clifton Court Forebay to reduce salmon and steelhead pre-screen loss to no more than 40 percent. DWR is currently implementing four interim methods and conducting studies to reduce predation on listed anadromous fish species in Clifton Court Forebay. In March 2019, DWR completed an in-depth study to evaluate dredging alternatives to reduce pre-screen loss of salmonids and sturgeon in Clifton Court Forebay.

In addition to predation in freshwater and estuarine habitats, predation in the ocean contributes to natural mortality of salmonids. They are also prey for pelagic fishes, birds, and a wide variety of marine mammals (including SRKW). It has been estimated that marine mammal predation of Chinook salmon off the West Coast of North America has more than doubled over the last 40 years (Chasco et al. 2017b). Resident salmon-eating killer whales consume the most Chinook salmon by biomass, but harbor seals consume the most individual Chinook salmon (typically smolts, Chasco et al. 2017b). In particular, they noted that southern Chinook salmon stocks ranging south from the Columbia River have been subject to the largest increases in predation, and that SRKW may be the most disadvantaged compared to other more northern resident killer whale populations given the northern migrations of Chinook salmon stocks in the ocean. Couture et al. (2024) found that NRKW and large pinnipeds, such as California and Steller sea lions, have been the most important predators of returning adult Chinook salmon in the Northeast Pacific in recent years, with predation mortality associated with NRKW doubling between 1979 and 2020. Ultimately, these increases in marine mammal predation of Chinook salmon could be masking recovery efforts for salmon stocks, and that competition with other marine mammals may be limiting the growth of the SRKW population (Chasco et al. 2017b).

6.13. Hatchery Effects

The Recovery Plan for Central Valley Chinook Salmon and Steelhead (National Marine Fisheries Service 2014b), identified hatchery effects as a primary stressor affecting the recovery of the species. This threat primarily affects the juvenile rearing and out-migration life stage of these species from the upper reaches of their watershed of origin through the Delta and bays.

More than 32 million fall-run Chinook salmon, 2 million CV spring-run Chinook salmon, 1 million late fall-run Chinook salmon, 0.25 million SR winter-run Chinook salmon, and 2 million CCV steelhead are released annually from six hatcheries producing anadromous salmonids in the Central Valley. All of these facilities are currently operated to partially mitigate for natural habitats that have already been permanently lost as a result of dam construction. The loss of this available habitat results in dramatic reductions in natural population abundance, which is partially mitigated through the operation of hatcheries. During spawning, hatchery- and natural-origin salmonids may compete for habitat, and interbreeding may reduce genetic integrity. Throughout juvenile rearing and out-migration, hatchery- and natural-origin salmonids may compete for habitat and food. When larger, juvenile hatchery-origin steelhead are released into the river, they may predate on smaller natural-origin salmonids.

The recent biological opinion on the hatchery and genetic management plan for the LSNFH (National Marine Fisheries Service 2017c) identified hatchery impacts to ESA-listed species in the Central Valley, which include:

1) Genetic impacts due to straying of hatchery fish and the subsequent interbreeding of hatchery fish with natural-origin fish.

2) High harvest-to-escapements ratios for natural stocks. California salmon fishing regulations are set according to the combined abundance of hatchery and natural stocks, which can lead to over exploitation and reduction in the abundance of wild populations that are indistinguishable and exist in the same system as hatchery populations.

3) Releasing large numbers of hatchery fish can also pose a threat to wild Chinook salmon and steelhead stocks through the spread of disease, genetic impacts, competition for food and other resources between hatchery and wild fish, predation of hatchery fish on wild fish, and increased fishing pressure on wild stocks.

4) In the ocean, limited marine carrying capacity has implications for naturally produced fish experiencing competition with hatchery production (Hatchery Scientific Review Group (HSRG) 2004). Increased salmonid competition in the marine environment may also decrease growth and size at maturity and reduce fecundity, egg size, age at maturity, and survival (Bigler et al. 1996). Hatchery production may be in excess of the marine carrying capacity, placing natural fish at a disadvantage by directly inhibiting their opportunity to recover (Northwest Power and Conservation Council 2003).

The multi-agency SAIL synthesis teams also identified some pathways by which hatchery effects are likely to SR winter-run Chinook salmon (and similar conceptual models can apply to CV spring-run Chinook salmon and CCV steelhead) as well as how they are likely to interact with other stressors. High densities of hatchery salmon can negatively impact natural-origin juvenile populations that may be smaller in size and numbers by causing increased competition for food (Windell et al. 2017). Returning adult hatchery fish can affect natural-origin adult spawners by competition for habitat or genetic introgression, reducing genetic fitness in the wild populations.

Hatchery management was identified as an important factor contributing to the listings of CV spring-run Chinook salmon and CCV steelhead (National Marine Fisheries Service 2014b). Most of California's anadromous fish hatcheries were constructed for mitigation purposes related to loss of habitat due to construction of hydroelectric dams and both SWP and CVP management,

and are therefore part of the environmental baseline. Statewide, there are nine hatchery facilities operated by the CDFW and two hatchery facilities operated by the USFWS. California's anadromous fish hatcheries produce ESA-listed Chinook salmon (SR winter-run Chinook salmon and CV spring-run Chinook salmon) and CCV steelhead. Production of non-listed CV fall-run Chinook salmon is the largest contributor of hatchery-origin Chinook salmon in the state, with a total combined release of nearly 30 million smolts annually.

In the Central Valley, the LSNFH, Coleman National Fish Hatchery, FRFH, Nimbus Fish Hatchery, and Mokelumne Fish Hatchery currently produce Chinook salmon and all except for the LSNFH also produce steelhead. Releasing large numbers of hatchery fish can pose a threat to natural-origin Chinook salmon populations through genetic impacts, displacement, competition for food and other resources, predation of hatchery fish on natural-origin fish, and increased fishing pressure on natural-origin stocks as a result of hatchery production (Waples 1991). The relatively low number of adult spawners needed to sustain a hatchery population can result in high harvest-to-escapement ratios in waters where fishing regulations are set according to hatchery population. This can lead to overexploitation and reduction in the size of natural-origin populations existing in the same system as hatchery populations due to incidental bycatch (McEwan 2001). Currently, hatchery produced fall-run Chinook salmon comprise the majority of fall-run Chinook salmon adults returning to Central Valley streams. Hatcheries in the Central Valley follow a 25 percent constant fractional marking of hatchery produced fall-run Chinook salmon juveniles. Any returning populations with adipose fin-clipped adult escapement greater than 25 percent would indicate that hatchery-produced fish are the predominant source in those spawning populations.

To maximize survival, and as a result of the degraded conditions of downstream migration corridors in the Central Valley, most Chinook salmon hatchery production has been routinely released off-site, significantly downstream of the hatchery or in the estuary. The exception is Coleman National Fish Hatchery, where hatchery managers have consistently implemented in-river releases. This approach was temporarily suspended during the recent drought (2014 and 2015), when environmental conditions in Battle Creek and the Upper Sacramento River were likely to result in adverse impacts and significant mortality. In order to circumvent these unfavorable conditions, the majority of the Chinook salmon produced by Coleman National Fish Hatchery and other Central Valley hatcheries were trucked and released offsite. Although this offsite release practice has improved survival rates and resulted in increased ocean harvest of hatchery fish, it has also led to widespread straying of hatchery fish throughout the Sacramento-San Joaquin system (California Hatchery Scientific Review Group 2012). The impacts of artificial propagation programs in the Central Valley are primarily genetic impacts due to straying of hatchery fish and the subsequent interbreeding of hatchery fish with natural-origin fish. Effects of the continuation of producing and releasing salmonids at these hatcheries are considered part of the environmental baseline.

Introgression of spring- and fall-run Chinook salmon and significant straying of adults from FRFH have posed a significant threat to the genetic integrity of natural spawning fall-run and CV spring-run Chinook salmon in other watersheds, such as the Upper Sacramento River and associated tributaries (National Marine Fisheries Service 2014b). The management of hatcheries, such as Nimbus Fish Hatchery and FRFH, can directly impact Chinook salmon and steelhead populations by oversaturating the natural carrying capacity of the limited habitat available below

dams. In the case of the Feather River, significant redd superimposition occurs in-river due to the inability to spatially separate CV spring-run and fall-run Chinook salmon adults. This concurrent spawning has led to hybridization between the CV spring-run and fall-run Chinook salmon in the Feather River.

Over the past several decades, the genetic integrity of CCV steelhead has diminished by increases in the proportion of hatchery fish relative to naturally produced fish, use of out-of-basin stocks for hatchery production, and straying of hatchery produced fish (National Marine Fisheries Service 2014b). Potential threats to natural-origin steelhead from hatchery programs include: (1) mortality in fisheries targeting hatchery-origin fish; (2) competition for prey and habitat; (3) predation by hatchery-origin fish; (4) disease transmission; and (5) genetic introgression by hatchery-origin fish that spawn naturally and interbreed with local natural-origin populations (National Marine Fisheries Service 2016b, d).

High densities of hatchery fish in some rivers may cause competition with natural-origin juvenile parr and smolts. This problem is likely to be greatest when hatchery smolts residualize (those that do not migrate to the ocean). How often this occurs in Central Valley rivers is unknown. What is known is that some hatchery smolts do stray into other rivers. For example, hatchery smolts have been documented in the Vaki Riverwatcher camera, moving upstream/downstream of Daguerre Point Dam on the Yuba River, which most likely originated from the FRFH. They do not appear to be residualizing upstream of the dam, as they do not remain upstream of the dam for long, based on Vaki counts and anecdotal information from angling and snorkel surveys, but their behavior below the dam is not tracked. In the Lower American River, some hatchery smolts appear to become “half-pounders”, but it is unknown how much time they spend in the river versus in the Delta or bays. Recent evaluations of these hatchery programs and Hatchery and Genetic Management Plans have proposed or recommended changes in hatchery policies and management to address these impacts (State Water Resources Control Board 2017a).

Hatcheries may also have short-term positive effects through supporting listed salmonid populations. Artificial propagation has been shown to be effective in bolstering the numbers of naturally-spawning fish in the short-term under specific scenarios. Artificial propagation programs can also aid in conserving genetic resources and guarding against catastrophic loss of naturally spawned populations at critically low abundance levels. For example, the LSNFH propagates SR winter-run Chinook salmon to conserve the genetic resources of a single fish population at low abundance and in danger of extinction. A potential complementary goal of the hatchery program is restoration of the ESU. This goal could be achieved by providing a source of SR winter-run Chinook salmon to re-establish naturally spawning populations in historical habitats. According to the Central Valley salmonid Recovery Plan (National Marine Fisheries Service 2014b), “The LSNFH winter-run Chinook salmon conservation program on the Upper Sacramento River is one of the most important reasons that Sacramento River winter-run Chinook salmon still persist.” Conservation hatcheries like LSNFH can contribute to the recovery of listed species. It is important to note that relative abundance is only one component of a VSP and managers must also consider the possible adverse impacts of hatchery influence in the long-run, such as reduced fitness of the population.

Hatcheries can also have positive effects through augmenting SRKW prey. There are over 300 hatchery programs in Washington, Oregon, California, and Idaho that produce and release

juvenile salmon that migrate through SRKW coastal and inland critical habitat. Funding through NMFS and the State of Washington has been used to increase regional hatchery production with the goal to enhance prey availability for SRKWs. One of the domestic actions associated with the 2019-2028 PST Agreement was to provide federal funding annually for increased hatchery production of SRKW prey. These additional releases are contributing towards the goal of increasing adult Chinook salmon abundance by 4-5 percent in coastal areas during the winter, and inland (Salish Sea) areas during the summer (National Marine Fisheries Service 2024d).

As described in Appendix G (U.S. Bureau of Reclamation 2023-2024), the USFWS has been engaged in efforts regarding Coleman National Fish Hatchery and LSNFH and their contribution to the management and restoration of Chinook salmon in the Sacramento River and Battle Creek. These efforts are: (1) improving LSNFH; (2) implementing the Battle Creek Reintroduction Plan; (3) designing a fish trapping and sorting facility at Coleman National Fish Hatchery; and (4) studying alternative release strategies for Coleman National Fish Hatchery produced fall-run Chinook salmon. Appendix G (U.S. Bureau of Reclamation 2023-2024) includes a brief description of each effort, including progress to date and expectations for completion and funding. All of these efforts are underway and at least partially funded, with most of the funding provided by Reclamation with additional funding and support from other partners.

Specific recent and ongoing actions for improving the LSNFH include:

1. During the droughts in 2014 and 2015, and at the request of NMFS and CDFW, the LSNFH increased production of SR winter-run Chinook salmon to compensate for expected high temperature-dependent mortality in the Sacramento River and re-instated the captive broodstock program. Also, Reclamation funded the rental of two commercial-size chillers to ensure adequate water temperatures for adult holding, egg incubation, and juvenile rearing. Those chillers were rented during the summer and fall and used on just a few occasions. Subsequently, Reclamation has funded a small permanent chiller to ensure temperatures for egg incubation only. Increased production started again in 2020 to address drought-related temperature conditions and has continued into 2024 to address egg-to-fry survival impacts related to Thiamine deficiency.

2. The USFWS partners with the CDFW for much of the monitoring for SR winter-run Chinook salmon on the Sacramento River. USFWS efforts include coded-wire tagging and marking LSNFH-produced SR winter-run Chinook salmon, acoustic tagging a subset of those fish, rotary screw trapping at Red Bluff Diversion Dam, and carcass surveys on the mainstem Sacramento River. Reclamation covers the costs for all of USFWS' efforts, mostly out of the operational funding agreement for Coleman National Fish Hatchery and LSNFH and the opinion monitoring agreement with the USFWS' Red Bluff Office. Both of these are long-term agreements with a history of renewal.

Specific ongoing actions for the Battle Creek Reintroduction Plan include:

1. In 2017, LSNFH withheld excess captive broodstock SR winter-run Chinook salmon. This occurred in case additional fish were needed to supplement the mainstem Sacramento River program because of drought conditions. The extra captive broodstock

were not needed for the Sacramento program, and the agencies decided to use those fish to produce juveniles for release into Battle Creek to jumpstart the reintroduction of SR winter-run Chinook salmon in advance of the implementation of the Battle Creek Reintroduction Plan and the complete restoration of Battle Creek. In the spring of 2018, Coleman National Fish Hatchery released 215,000 juvenile SR winter-run Chinook salmon into the North Fork of Battle Creek. Subsequently, the agencies decided to continue this jumpstart program and Coleman National Fish Hatchery has integrated the production of approximately 200,000 SR winter-run Chinook salmon juveniles into its annual operations and approximately 200,000 SR winter-run Chinook salmon were released in the North Fork of Battle creek again in 2019. This currently involves spawning broodstock and rearing eggs at LSNFH, then transferring fry to Coleman National Fish Hatchery for further rearing and release. Subsequent releases into Battle Creek of 168,219; 214,943; and 132,929 SR winter-run Chinook salmon were made in 2020, 2021, and 2022, respectively (U.S. Fish and Wildlife Service 2021, 2022, 2023).

Specific ongoing actions for constructing a fish trapping and sorting facility at Coleman National Fish Hatchery include:

1. The USFWS assembled a multi-agency team to design a fish trapping and sorting facility at the Coleman National Fish Hatchery weir to minimize handling and migration delay of listed species during Coleman National Fish Hatchery's fall-run Chinook salmon spawning operations, and to allow for passage, monitoring, and management of fish passage during times when spawning operations are not taking place. The project is currently envisioned to be constructed in two phases, with the first phase establishing the ability to pass fish through the fish sorting facility year round, which would allow for monitoring and management during times when the spawning operations are not being conducted. The second phase would allow for selective bypassing of the spawning building during spawning operations and automation of many of the processes. To date, with Reclamation funding and input from partner agencies, the USFWS has completed 65 percent design of Phase 1, with anticipated 100 percent design completion in August, 2019.

Specific ongoing actions for studying alternative release strategies for Coleman National Fish Hatchery produced fall-run Chinook salmon include:

1. Evaluate alternative release strategies for Coleman National Fish Hatchery fall-run Chinook salmon to determine if trucking to an alternative release site can increase juvenile survival to the ocean and adult returns to the Sacramento River without unacceptable levels of straying.

6.13.1. Nimbus Hatchery

Generally speaking, effects range from beneficial to negative for programs that use local fish for hatchery broodstock and from negligible to negative when a program does not use local fish for broodstock. Hatchery programs can benefit population viability but only if they use genetic resources that represent the ecological and genetic diversity of the target or affected natural population(s). When hatchery programs use genetic resources that do not represent the ecological and genetic diversity of the target or affected natural population(s), NMFS is particularly

interested in how effective the program will be at isolating hatchery fish and avoiding co-occurrence and effects that potentially disadvantage fish from natural populations.

Nimbus Fish Hatchery on the American River has been a substantial producer of steelhead in the Central Valley since 1955 (Leitritz 1970) and, during the first several decades of operation, broodstock was imported periodically from coastal steelhead populations, including the Eel, Mad, and Russian rivers (Lee and Chilton 2007). The effects of this out-of-basin stocking are apparent in both individual and population analyses, in which the Nimbus Fish Hatchery and American River populations are intermediate between the coastal steelhead populations and all other Central Valley populations (Pearse and Garza 2015). Notably, the closest relationship of the American River populations outside of the Central Valley is to fish from Northern California, in the group that includes the Eel and Mad rivers, rather than to more geographically proximate populations in the San Francisco Bay.

For this reason, the Nimbus Fish Hatchery stock is not currently part of the CCV steelhead DPS, and its impacts to the natural American River population include both genetic and behavioral effects (Myers et al. 2004). As described in Pearsons et al. (2007), the selective pressures in hatcheries are dramatically different than in the natural environment, which can result in genetic differences between hatchery and wild fish (Weber and Fausch 2003) and, subsequently, differences in behavior (Metcalfe et al. 2003).

The continued use of out-of-basin (Eel River/Mad River) broodstock is concerning, particularly for Central Valley populations that are not geographically proximate to the American River. According to Pearse and Garza (2015), "The clustering of other Central Valley below-barrier populations with Nimbus and American River samples, particularly those from the Calaveras and Tuolumne rivers, indicates that introgression of natural populations by fish with coastal steelhead ancestry has occurred through straying/migration of Nimbus Hatchery steelhead." This issue has been perpetuated by the long-time practice of releasing hatchery steelhead production far downstream from the hatchery (e.g., at Discovery Park, which is adjacent to the confluence with the Sacramento River; approximately river mile 0), which contributes to adult returns straying to non-natal rivers and creeks thereby spreading out-of-basin genetics throughout the Central Valley. The California Hatchery Scientific Review Group made the following comments about these practices (California Hatchery Scientific Review Group 2012):

> *"There is evidence that Nimbus Hatchery steelhead may stray throughout the Central Valley and spawn naturally in other streams where hatcheries are not present. Both juvenile releases and hatchery strays from Nimbus have the potential to affect naturally spawning steelhead in other watersheds."*
>
> *"Although this is intended to be a segregated program, genetic evidence confirms that Eel River genes are throughout the Sacramento System."*
>
> *"The current broodstock for this program should be replaced with an alternative broodstock that is appropriate for the American River."*
>
> *"Investigate straying rates for Jibboom release site (Discovery Park). We do not consider a release site 21 miles downstream of the hatchery to be an on-station release. Transporting and releasing juveniles to areas outside of the American River or to the Lower American*

River should be discontinued. Juvenile fish should be released at the hatchery, or if not possible, as far upstream in the American River from the confluence of the Sacramento River as possible to reduce adult straying and increase the number of adults returning to the hatchery. Consider necessary facility modifications or equipment purchases that will facilitate on-site releases. Release locations for steelhead may take into consideration ecological and predation effects on other fish populations but should not compromise homing of adults to the hatchery."

The Nimbus Fish Hatchery Steelhead Program has been working to address these concerns.

Regarding the release site concern, in recent years, juvenile CCV steelhead from Nimbus Fish Hatchery have been released at locations further upstream than Discovery Park. In March 2019, all of the steelhead production from Nimbus Fish Hatchery was released at the Sunrise location (approximately river mile 20). This location is just a few miles downstream from the hatchery and is expected to minimize straying, relative to the Discovery Park location.

Assuming 100 percent of the steelhead production continues to be released at the Sunrise location, the Nimbus Fish Hatchery Steelhead Program is considered a stressor of medium magnitude. However, if the release location shifts back to Discovery Park or further downstream (Bay-Delta), then the program would be considered a high magnitude stressor, given the known genetic impacts to steelhead throughout the Sacramento river basin associated with the use of Eel River origin broodstock at Nimbus Fish Hatchery.

6.14. Harvest

The following discussions of harvest impacts for SR winter-run Chinook salmon, CV spring-run Chinook salmon, and CCV steelhead were, in large part, taken from the most recent NMFS 5-year status review reports for each species (National Marine Fisheries Service 2016a, b, c).

6.14.1. Ocean and Freshwater Harvest of Sacramento River Winter-Run Chinook Salmon

Sacramento River winter-run Chinook salmon have a more southerly ocean distribution relative to other California Chinook salmon stocks and are primarily impacted by fisheries south of Point Arena, California. Sacramento River winter-run Chinook salmon age-3 ocean fishery impact rate estimates for the region south of Point Arena (an approximation of the exploitation rate) are currently available for 2000 to 2017, and have remained relatively stable over this period, averaging 16 percent. Ocean commercial fisheries in 2008 and 2009 were closed south of Point Arena owing to the collapse of the SR fall-run Chinook salmon stock, and insufficient data (i.e., insufficient coded-wire tag recoveries) exist for estimating an SR winter-run Chinook salmon impact rate in 2010. If years 2008 to 2010 are omitted, the average age-3 impact rate is 18 percent (Pacific Fishery Management Council 2019). Ocean commercial fisheries were also recently closed in 2023 and 2024.

There have been several layers of ocean salmon fishery regulations implemented to protect SR winter-run Chinook salmon beginning in the early 1990s. For example, a substantial portion of the SR winter-run Chinook salmon ocean harvest impacts used to occur in February and March

recreational fisheries south of Point Arena, but fisheries at that time of the year have been closed since the early 2000s. In general, under the provisions of the biological opinions issued since 2004 (National Marine Fisheries Service 2018b), ocean salmon fishing remains closed from late fall through April for the commercial fishery and March for the recreational fishery, and sector-specific size limits are in place as additional protective measures.

O'Farrell and Satterthwaite (2015) hindcasted SR winter-run Chinook salmon age-3 ocean impact rates back to 1978, extending the impact rate time series beyond the range of years where direct estimation is possible (2000–2013). Their results suggest that there were substantial reductions in ocean impact rates prior to 2000 and that the highest impact rates occurred in a period between the mid-1980s and late-1990s.

NMFS has completed several ESA consultations regarding the impacts of the ocean salmon fishery on SR winter-run Chinook salmon. The most recent and currently applicable biological opinion was completed in March 2018. That opinion analyzed a proposed new abundance-based control. The harvest control rule specifies the maximum allowable age-3 impact rate on the basis of a forecast of the SR winter-run Chinook salmon age-3 escapement in the absence of fisheries. The limits to the impact rate imposed by the harvest control rule is an additional control on ocean fisheries which still includes previously existing constraints on fishery opening and closing dates and minimum size limits south of Point Arena. From 2012 to 2019, the SR winter-run Chinook salmon harvest control rule has specified maximum allowable forecast impact rates ranging from 12.9 percent to 19.9 percent (Pacific Fishery Management Council 2019).

What little SR winter-run Chinook salmon freshwater harvest that existed historically was essentially eliminated beginning in 2002, when Sacramento Basin Chinook salmon fishery season openings were adjusted so that there would be little temporal overlap with the SR winter-run Chinook salmon spawning migration and spawning period. However, early arriving fish may still be harvested prior to January 1. Additionally, higher densities of fish in this portion of the river may lead to higher early harvest rates. Higher densities of fish, particularly below dams, likely create opportunities for both illegal poaching of salmon and the inadvertent or intentional snagging of fish. In addition, the Upper Sacramento River supports substantial angling pressure for rainbow trout. Rainbow trout fishers tend to concentrate in locations and at times where SR winter-run Chinook salmon are actively spawning (and therefore concentrated and more susceptible to impacts). By law, any SR winter-run Chinook salmon inadvertently hooked in this section of river must be released without removing it from the water. However, SR winter-run Chinook salmon are impacted as a result of disturbance and the process of hook-and-release. In addition, because the taking of salmon is permitted after August 1, some late spawning SR winter-run Chinook salmon may be taken.

6.14.2. Ocean Harvest of Central Valley Spring-Run Chinook Salmon

The viability of the CV spring-run Chinook salmon ESU has deteriorated since it was listed under the ESA (National Marine Fisheries Service 2016a, Johnson et al. 2023b). The largest impacts are likely due to the 2012–2015 and 2020–2022 freshwater drought conditions and unusually warm ocean conditions experienced by these cohorts. Attempts have been made (Grover et al. 2004) to estimate CV spring-run Chinook salmon ocean fishery exploitation rates by capturing and tagging natural-origin CV spring-run Chinook salmon from Butte Creek, but

due to the low number of coded-wire tag recoveries, the uncertainty of these estimates is too high for them to be of value. Central Valley spring-run Chinook salmon have a relatively broad ocean distribution from central California to Cape Falcon, Oregon, that is similar to that of Sacramento River fall-run Chinook salmon, thus trends in the fall-run Chinook salmon ocean harvest rate are thought to provide a reasonable proxy for trends in the CV spring-run Chinook salmon ocean harvest rate. While the fall-run Chinook salmon ocean harvest rate can provide information on trends in CV spring-run Chinook salmon fishing mortality, it is likely that CV spring-run Chinook salmon experience lower overall fishing mortality. If maturation rates are similar between CV spring-run and fall-run Chinook salmon, the ocean exploitation rate on CV spring-run Chinook salmon would be lower than fall-run Chinook salmon in the last year of life because CV spring-run Chinook salmon escape ocean fisheries in the spring, prior to the most extensive ocean salmon fisheries in summer.

The fall-run Chinook salmon ocean harvest rate index peaked in the late 1980s and early 1990s, but then declined. With the closure of nearly all Chinook salmon ocean fisheries south of Cape Falcon in 2008 and 2009, the index dropped to 6 percent and 1 percent respectively. While ocean fisheries resumed in 2010, commercial fishing opportunity was severely constrained, particularly off California, resulting in a harvest rate index of 16 percent. Since 2011, ocean salmon fisheries in California and Oregon have had more typical levels of fishing opportunity. The average CV fall-run Chinook salmon ocean harvest rate from 2011 to 2018 was 46 percent, which is generally similar to levels observed from the late 1990s to 2007. In addition, NMFS determined that the management framework for SR winter-run Chinook salmon that includes the updated harvest control rule and size and season limits contains equivalent and/or additional restrictions on the fishery compared to previous management measures and is more responsive than prior management frameworks to information related to the status of CV spring-run Chinook salmon by accounting for changes in freshwater conditions in the Central Valley for SR winter-run Chinook salmon. The CV spring-run Chinook salmon spawning migration largely concludes before the mid- to late-summer opening of freshwater salmon fisheries in the Sacramento Basin, and salmon fishing is prohibited altogether on Butte, Deer, and Mill creeks, suggesting in-river fishery impacts on CV spring-run Chinook salmon are relatively minor. In summary, the available information suggests that ocean fishery impacts have not changed appreciably since the 2016 salmon and steelhead status review update concluding it is highly unlikely that harvest resulted in overutilization of this ESU (National Marine Fisheries Service 2016a).

6.14.3. Salmon Harvest Actions

Salmon fisheries that intercept fish that would otherwise pass through the action area and become available prey for SRKWs occur all along the Pacific Coast from Alaska to California. In past harvest consultations, including Puget Sound salmon fisheries (National Marine Fisheries Service 2010a, 2014a, 2015a, 2016b, 2017b, 2018c, 2019a, 2020a, 2021d, 2022c, 2023c), PFMC-area salmon fisheries (National Marine Fisheries Service 2008d, 2020b, 2021b), the Pacific Salmon Treaty (PST) 2009 Agreement (National Marine Fisheries Service 2008c), and the *United States* v. *Oregon* Management Agreements (National Marine Fisheries Service 2008b, 2018a), we characterized the short-term and long-term effects these salmon fisheries have on the SRKWs via prey reduction from fishery operations. We considered the short-term direct effects to whales resulting from reductions in Chinook salmon abundance that occur during a specified year and the long-term indirect effects to whales that could result if harvest affected viability of

the salmon stock over time by decreasing the number of fish that escape to spawn. We first review individual fishery impacts and biological opinions using evolving methodologies, and then provide a comprehensive review of all fisheries to estimate baseline prey availability. The comprehensive fishery analysis uses updated methodology so that the assessments of multiple fisheries are comparable.

Salmon fisheries off Alaska, Canada, Washington, and Oregon are managed under the PST. The PST has annex agreements that provide detailed implementation provisions that are renegotiated periodically for multi-year periods ("PST Agreement"). The 2019–2028 PST Agreement currently in effect (Pacific Salmon Commission 2023) includes provisions limiting harvest impacts in all Chinook salmon fisheries and refining the management of coho, sockeye, chum, and pink salmon within its scope. This PST Agreement includes reductions in the allowable annual catch of Chinook salmon in the Southeast Alaska, Canadian West Coast of Vancouver Island, and Northern British Columbia fisheries by up to 7.5 and 12.5 percent, respectively, compared to the previous (2009–2018) PST Agreement. The level of reduction depends on the Chinook salmon abundance in a particular year. This comes on top of the reductions of 15 and 30 percent for those same fisheries that occurred as a result of the 2009–2018 PST Agreement. These reductions should result in more salmon returning to the more southerly United States' Pacific Coast portion of the exclusive economic zone than under prior PST Agreements. Therefore, under the new PST Agreement, the fisheries should have a smaller effect in terms of reducing SRKW prey than under the previous PST Agreement, which is seen in the analyses described below.

Salmon fisheries in the southern U.S. are managed to meet specific objectives for ESA-listed and non-listed salmon ESUs and, as a result, can have impacts lower than what is allowed by the PST Agreement, particularly for Chinook salmon. Fisheries in the exclusive economic zone off the West Coast of the United States are managed by the PFMC (or the North Pacific Fishery Management Council off Alaska) and NMFS under the MSA. NMFS has issued biological opinions addressing the effects of these fisheries on all affected ESA-listed species including SRKWs, and fisheries are managed consistent with the proposed actions and incidental take statements in these opinions.

In 2019, NMFS reinitiated consultation to consider effects of PFMC-area ocean salmon fisheries on SRKWs given substantial new information, and the PFMC formed an Ad Hoc SRKW Workgroup to reassess fishery effects on SRKWs and develop a long-term approach potentially including proposed conservation measure(s) or management tool(s) that limit PFMC salmon fishery impacts on Chinook salmon prey available for SRKWs as needed. The PFMC adopted Amendment 21 to address effects of PFMC-area ocean salmon fisheries on the Chinook salmon prey base of SRKWs, based on recommendations from the Ad Hoc SRKW Workgroup. In 2021, NMFS consulted on the authorization of the West Coast ocean salmon fisheries through approval of the Pacific Salmon Fishery Management Plan (FMP) including Amendment 21 and implementation of the Plan through regulations and concluded this action was not likely to jeopardize SRKW. NMFS ultimately approved the amendment (86 FR 51017 2021). The Amendment established a threshold representing a low pre-fishing Chinook salmon abundance in the North of Falcon area (including the exclusive economic zone and state ocean waters), below which the PFMC and states will implement specific management measures (National Marine Fisheries Service 2021b). The North of Falcon abundance threshold is equal to the arithmetic

mean of the seven lowest years of the estimated starting abundance (prior to fishing) from the Fishery Regulatory Assessment Model (see PFMC [2020] for more details or PFMC [2022]), which also included years when SRKWs were in varied health and consecutive years of low Chinook abundance (given reproductive success is likely reliant on several years of optimal prey availability). The threshold may be revised prior to the start of the fishing season using current data and updated methods if determined to be the best available science by the STT, SSC, and the PFMC (Pacific Fishery Management Council 2022). The threshold was updated in 2022 to incorporate new scientific information, was approved by the PFMC, and is currently estimated[14] at 623,000 Chinook salmon.

Under the Amendment, each year, the preseason estimate of pre-fishing Chinook salmon abundance for the upcoming fishing year will be compared to the threshold. In years when the projected preseason abundance of Chinook salmon in the North of Falcon area falls below the low abundance threshold, multiple management actions (e.g., quota adjustments and spatial/temporal closures) will be implemented through annual regulations within the North of Falcon area, with the goal of limiting effects of the fishery on SRKWs. NMFS concluded in the biological opinion (National Marine Fisheries Service 2021b) that the FMP including Amendment 21 is responsive to the abundance of Chinook salmon by requiring that fisheries be designed to meet FMP conservation objectives and addresses the needs of the whales by limiting prey removal from the fisheries in North of Falcon areas during years with low Chinook salmon abundance. Amendment 21 will also reduce the potential for competition between fisheries and SRKWs in times and areas where/when the fisheries and whales overlap, and when Chinook salmon abundance is low. Therefore, NMFS concluded that fisheries managed consistent with the proposed action were not likely to jeopardize the continued existence of the SRKW DPS or destroy or adversely modify its designated critical habitat (National Marine Fisheries Service 2021b). In addition to limiting the reduction in prey availability on the coast, Amendment 21 may limit the reductions of prey by PFMC fisheries on Salish Sea prey in years with low salmon abundance, compared to the FMP without Amendment 21, but the extent of the impacts of the Amendment on inland prey availability specifically is unknown. In years when Chinook salmon abundance is above the threshold, we anticipate similar reductions in prey availability attributed to the PFMC fisheries as those observed in the 10-year period considered in the NMFS' 2021 opinion into the foreseeable future.

Recent biological opinions considering the effects of Puget Sound salmon fisheries on SRKWs have considered percent reductions in Chinook salmon prey expected from the fisheries. In the most recent biological opinion on federal actions related to the salmon fisheries in Puget Sound (National Marine Fisheries Service 2023b), NMFS estimated that the percent reductions of

[14] This threshold is the arithmetic mean of the seven lowest years of pre-fishing Chinook salmon abundance estimated to be present on October 1 in the area North of Cape Falcon (1994–1996, 1998–2000, and 2007), and are years where there was a general mix of SRKW status (i.e., consisting of a spectrum of risk), with 2 relatively good status years (1994 and 2007) and 5 years of fair or poor SRKW status. The low abundance threshold the PFMC developed for Amendment 21 also includes two periods when there were multiple and consecutive years of low Chinook salmon abundance (1995–1996 and 1998–2000), given reproductive success is likely reliant on several years of optimal prey availability as female body condition and energy reserves potentially affect reproduction and/or result in reproductive failure at multiple stages. Should updates or changes occur to models that affect these historic estimates of abundance, the threshold should be recalculated using the same methodology.

Chinook salmon from the tribal and state Puget Sound fisheries in 2009–2018 in inland waters of Washington annually were estimated to range from 3.3 percent to 7.0 percent[15] (average of 4.7 percent) with the greatest reductions occurring in July-September. Percent reductions in overall abundance from the Puget Sound salmon fisheries of Chinook salmon in the Salish Sea in 2023–2024 were predicted to be similar to average reductions and were estimated to be 4.9 percent relative to the starting abundance. The pre-season estimate for abundance of age 3-5 Chinook salmon in the Salish Sea for 2023–2024 was approximately 1,053,300 fish—greater than the estimated abundance for the retrospective time period (2009–2018) post-season average of approximately 980,300 fish. Although some of the prey reduction due to the Puget Sound fisheries occurs in an area known for high SRKW use and is considered a foraging hot spot (an area where SRKWs are frequently detected or sighted such as the west side of San Juan Island), in recent years recreational fishery restrictions in the summer and winter, very limited commercial fishing, and limited tribal fishing, were expected to limit the impacts in this hot spot. Also, additional management measures were implemented to reduce impacts of vessel and noise disturbance.

Some directed fishery actions may be offset by hatchery production. For example, the *U.S.* v. *Oregon* action was determined not likely to adversely affect SRKWs because hatchery production included as part of that action offset the in-river harvest reductions (i.e., reductions occur after Chinook salmon are no longer available as prey). Columbia River salmon stocks are currently managed in line with their recovery plans and the status of several stocks and ESUs have improved under the fishing regime, and hatchery programs are managed in ways to minimize effects to listed species (National Marine Fisheries Service 2018a). Similarly, the federal Columbia River System action was determined not likely to adversely affect SRKWs because part of the action included production of hatchery Chinook salmon that more than offset Chinook salmon mortality (National Marine Fisheries Service 2008b, 2020b).

Finally, fisheries other than directed salmon fisheries may also catch Chinook salmon as bycatch, and this may include Chinook salmon that would otherwise pass through the action area. Specifically, the PFMC groundfish fisheries catch Chinook salmon as bycatch, and the most recent biological opinion found the PFMC groundfish fishery is likely to adversely affect, but not jeopardize, ESA-listed Chinook salmon (National Marine Fisheries Service 2017c). Coastwide, while PFMC groundfish fisheries take an average of approximately 7,000 Chinook salmon per year, the fisheries are not likely to adversely affect SRKW, given (a) the wide geographic expanse of the area and relatively low bycatch numbers and (b) the relatively high number of young (under age 3) Chinook salmon taken, which are not the preferred prey of SRKW (National Marine Fisheries Service 2022d). Recreational halibut fisheries in the Salish Sea have very limited bycatch mortality of Chinook salmon (less than two Chinook salmon on average each year), commercial and tribal halibut fisheries likely do not have incidental catch, and bottomfish and shrimp trawl fisheries have limited incidental take (lethal take of up to 50 Chinook salmon, see Section 2.4.1 Environmental Baseline for Puget Sound Chinook and Steelhead in NMFS [2023b]).

[15] The methodology to estimate this percent reduction differs from the PFMC SRKW Ad Hoc Workgroup and warrants caution in comparing impacts.

The directed salmon harvest biological opinions referenced above concluded that the harvest actions cause prey reductions in a given year and were likely to adversely affect but were not likely to jeopardize the continued existence of ESA-listed Chinook salmon or SRKWs. Additionally, Amendment 21 to the FMP for the ocean salmon fisheries addresses SRKW prey needs by limiting prey removal from the fisheries in North of Falcon areas in low abundance years, and could limit reduction of Salish sea prey availability by PFMC fisheries in those years.

Size and age structure of Chinook salmon has substantially changed across the Northeast Pacific Ocean (Ohlberger et al. 2018). Since the late 1970s, adult Chinook salmon (ocean ages 4 and 5) along most of the eastern North Pacific Ocean are becoming smaller, whereas the size of age 2 fish are generally increasing (Ohlberger et al. 2018). Additionally, most of the Chinook salmon populations from Oregon to Alaska have shown declines in the proportions of age 4- and 5-year-olds and an increase in the proportion of 2-year-olds; the mean age of Chinook salmon in the majority of the populations has declined over time. Populations along the coast from western Alaska to northern Oregon had strong declining size trends of ocean-4 fish, including wild and hatchery fish. For Puget Sound Chinook salmon (primarily hatchery origin), there were little or weak trends in size-at-age of 4-year-olds and the declining trend in the proportion of older ages in Washington stocks was also observed but slightly weaker than that in Alaska populations (Ohlberger et al. 2018). The authors suggest the reasons for this shift may be largely due to direct effects from size-selective removal by marine mammals and fisheries, followed by evolutionary changes toward these smaller sizes and early maturation (Ohlberger et al. 2018). Smaller fish have a lower total energy value than larger ones (O'Neill et al. 2014). Therefore, SRKWs need to consume more salmon in order to meet their caloric needs as a result of a decrease in average size of older Chinook salmon.

6.14.4. Harvest of Steelhead

In an attempt to minimize potential negative behavioral and genetic interactions with natural-origin steelhead, CDFW has increased the bag limit for hatchery steelhead on several popular rivers in the Central Valley. The following is a chronological rundown of changes in daily bag and possession limits that have occurred since March 1, 2010, which was the effective date of the 2010–2011 regulations cycle:

- Prior to March 1, 2010, the daily bag and possession limit in the Sacramento River system, including the Lower Mokelumne River, was one steelhead in the bag and one in possession.
- Effective March 1, 2010, the steelhead daily bag and possession limit on the mainstem Sacramento and American rivers increased to a daily bag of two hatchery steelhead and a possession limit of four hatchery steelhead. On the Feather and Mokelumne rivers, the daily bag and possession limit remained at one hatchery steelhead in the bag, and one hatchery steelhead in possession.
- On March 1, 2013, the steelhead daily bag and possession limit on the Feather River increased to two and four hatchery steelhead, respectively.
- In the current regulations cycle with an effective date of March 1, 2016, the steelhead daily bag and possession limit remains at two and four, respectively, on the Sacramento, American, and Feather rivers; and at one and one, respectively, on the Mokelumne River.

The 2012–2016 drought conditions affected some steelhead fishing opportunities for this DPS. For example, the California Fish and Game Commission imposed an emergency fishery closure on the American River during February of 2014. The closure ended in April of that year.

The regulation changes reviewed above for steelhead fishing in the Central Valley suggest that there is the potential for a change in harvest dynamic over the past several years. The overall trend has been to incrementally increase the opportunity for harvest of hatchery-origin steelhead by increasing the daily bag and possession limits. The rationale behind encouraging more harvest of hatchery-origin steelhead is to minimize potential negative behavioral and genetic interactions with natural-origin steelhead. In addition, retention of hatchery-origin steelhead in the Central Valley is typically very low. Yet, the purpose of the hatchery programs is to provide a harvestable fishery resource. Thus, CDFW would like to see more of that resource utilized for its intended consumptive purpose.

CDFW performs angler surveys on Central Valley streams, and data from these surveys are used to estimate steelhead harvest and fishing effort. However, these estimates do not appear to be regularly reported. Available data on angler retention of hatchery-origin steelhead suggest an increase in retention since the 2010–2011 regulatory cycle (California Department of Fish and Wildlife 2016b). Mean retention from 2007 to 2008 through 2009 to 2010 was 13.1 percent, while mean retention from 2010 to 2011 through 2015 to 2016 was 20.4 percent. These means do not differ significantly, however (2-tailed t-test: $t = -1.82$, $p = 0.11$; no significant departure from normality in sample data; variances not significantly different). This analysis may possibly be improved by using expanded catch and retention data for each regulatory year (National Marine Fisheries Service 2016b). Steelhead are rarely caught in ocean fisheries and retention of steelhead in non-treaty commercial ocean fisheries is currently prohibited.

6.14.5. Harvest of sDPS Green Sturgeon

Starting in 2006, sDPS green sturgeon harvest was prohibited by CDFW. California has established specific rules to protect sDPS green sturgeon, prohibiting fishing for green or white sturgeon year-round in the mainstem Sacramento River from Highway 162 (river mile 176) to Keswick Dam (river mile 302) and Yolo Bypass, prohibiting the removal of incidentally hooked sDPS green sturgeon from the water, only allowing the use of barbless hooks, prohibiting use of wire leaders and snares, and increasing fines for poaching (National Marine Fisheries Service 2018e).

6.14.6. Southern Resident Killer Whale Entrapment Entanglement in Fishing Gear

Drowning from accidental entanglements in nets and longlines is a minor source of fishing related mortality in killer whales, although not all incidents may be reported. Two killer whales have been recorded entangled in Dungeness crab commercial trap fishery gear off California (a transient in 2015 and unknown ecotype in 2016, National Marine Fisheries Service 2016f). In 2018, Fisheries and Oceans Canada disentangled a transient killer whale entangled in commercial prawn gear near Salt Spring Island, British Columbia (NMFS strandings data, unpublished). In 2013, a NRKW stranded in British Columbia and a fish hook was observed in its colon, but had no evidence of perforation or mucosal ulceration (Raverty et al. 2020). In 1977, a SRKW (L8) drowned in a net and recreational fishing lures and lines were found in the

stomach upon necropsy. Typically, killer whales are able to avoid nets by swimming around or underneath them (Jacobsen 1986, Matkin 1994), and not all entanglements automatically result in death or injury. For example, one killer whale (unknown ecotype) was reported interacting with a salmon gillnet in British Columbia in 1994, but did not get entangled (Guenther et al. 1995). More recently, J39, a young male SRKW in J pod, was observed with a salmon flasher hooked in his mouth during the summer of 2015 around the San Juan Islands, which subsequently fell out with no signs of injury or infection.

Entanglements of marine mammals in fishing gear must be reported in accordance with the Marine Mammal Protection Act. Section 118 of the Marine Mammal Protection Act established the Marine Mammal Authorization Program in 1994. Under the Marine Mammal Authorization Program, all fishers are required to report any incidental taking (injuries or mortalities) of marine mammals during fishing operations. Any animal that ingests fishing gear or is released with fishing gear entangled, trailing, or perforating any part of the body is considered injured, and must be reported.[16] No entanglements, injuries or mortalities of SRKW have been reported in recent years.

6.15. Water Quality

Current land use in the Sacramento river basin and Delta has seen a dramatic increase in urbanization, industrial activity, and agriculture in the last century. In a Sacramento river basin-wide study, areas with relatively high concentrations of agricultural activity as well as areas that had previously experienced mining activity showed increased concentrations of dissolved solids and nitrite plus nitrate (Domagalski et al. 2000). Varying concentrations of mercury and methylmercury have also been found throughout the Sacramento river basin (Domagalski et al. 2000). Concentrations of these contaminants were greatest downstream of previous mining sites (primarily Cache Creek). Both studies showed lower concentrations of contaminants in the American River as compared to other sites sampled in the Sacramento river basin.

Multiple studies have documented high levels of contaminants in the Delta such as PCBs, organochlorine pesticides, PAHs, selenium, and mercury, among others (Stewart et al. 2004, Leatherbarrow et al. 2005, Brooks et al. 2012), suggesting that fish are exposed to them. The inability to characterize concentrations and loading dynamics makes it difficult to quantify transport and total contaminant loading in the system (Johnson et al. 2010). Additionally, numerous discharges of treated wastewater from sanitation wastewater treatment plants (e.g., Cities of Tracy, Stockton, Manteca, Lathrop, Modesto, Turlock, Riverbank, Oakdale, Ripon, Mountain House, and the Town of Discovery Bay) and the untreated discharge of numerous agricultural wasteways are emptied into the waters of the San Joaquin River and the channels of the South Delta. This leads to cumulative additions to the system of thermal effluent loads as well as cumulative loads of potential contaminants (i.e., selenium, boron, endocrine disruptors, pesticides, biostimulatory compounds, etc.).

[16] See reporting requirements and procedures at 50 CFR 229.6 and https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-authorization-program#reporting-a-death-or-injury-of-a-marine-mammal-during-commercial-fishing-operations.

Metals, PCBs, and hydrocarbons (typically oil and grease) are common urban contaminants that are introduced to aquatic systems via nonpoint-source stormwater drainage, industrial discharges, and municipal wastewater discharges. Many of these contaminants readily adhere to sediment particles and tend to settle out of solution relatively close to the primary source of contaminants. PCBs are persistent, adsorb to soil and organic matter, and accumulate in the food web. Lead and other metals also will adhere to particulates and can bioaccumulate to levels sufficient to cause adverse biological effects. Mercury is also present in the Sacramento River system and could be sequestered in riverbed sediments. Hydrocarbons biodegrade over time in an aqueous environment and do not tend to bioaccumulate or persist in aquatic systems.

Freshwater contamination is also a concern because it may contaminate salmon that are later consumed by the SRKWs in marine habitats. Chinook salmon contain higher levels of some contaminants than other salmon species, however levels can vary considerably among populations. Mongillo et al. (2016) reported data for salmon populations along the west coast of North America, from Alaska to California, and found marine distribution was a large factor affecting persistent pollutant accumulation. They found higher concentrations of persistent pollutants in Chinook salmon populations that feed in close proximity to land-based sources of contaminants. There is some information available for contaminant levels of Chinook salmon in inland waters (i.e., Krahn et al. 2007, O'Neill and West 2009, Veldhoen et al. 2010, Mongillo et al. 2016). Some of the highest levels of certain pollutants were observed in Chinook salmon from Puget Sound and the Harrison River (a tributary to the Fraser River in British Columbia, Canada; Mongillo et al. 2016). These populations are primarily distributed within the urbanized waters of the Salish Sea and along the west coast of Vancouver Island (Fisheries and Oceans Canada 1999, Weitkamp 2010). However, populations of Chinook salmon that originated from the developed Fraser River and had a more northern distribution in the coastal waters of British Columbia and Alaska (Fisheries and Oceans Canada 1999) had much lower concentrations of certain contaminants than salmon populations with more southern distributions like those from the Salish Sea and southern West Coast of the United States (Mongillo et al. 2016). A recent study found higher levels of 4-nonylphenol in SRKWs compared to Bigg's killer whales which could be related to their greater association with an estuarine food chain (Lee et al. 2023b). Additionally, O'Neill and West (2009) discovered elevated concentrations of PCBs in Puget Sound Chinook salmon compared to those outside Puget Sound. Similarly, J pod (the SRKW pod most frequently seen in Puget Sound) has also been found to have higher levels of PCBs, consistent with these higher PCB concentrations in Puget Sound Chinook salmon (O'Neill et al. 2006, Krahn et al. 2007). Intermediate levels of PCBs were measured in California and Oregon populations, but Chinook salmon originating from California have been measured to have higher concentrations of DDTs (dichlorodiphenyltrichloroethane, (O'Neill et al. 2006, Mongillo et al. 2016). Therefore, SRKW prey is highly contaminated, causing contamination in the whales themselves. Build-up of pollutants can lead to adverse health effects in mammals (see Toxic Chemical section in Section 4.9.3.3). Nutritional stress, potentially due to periods of low prey availability or in combination with other factors, could cause SRKWs to metabolize blubber, which can redistribute pollutants to other tissues and may cause toxicity. Pollutants are also released during gestation and lactation which can impact calves (Noren et al. 2023).

Marine construction actions have implications for prey and water quality. For example, a recent section 7(a)(2) consultation on removal and replacement of two breakwaters near Port Townsend, Washington at Point Hudson was determined to likely adversely affect, but not

jeopardize, SRKWs and their critical habitat, though the project may have positive impacts on prey quality (National Marine Fisheries Service 2022b). As part of removal, creosote-treated piles will be replaced with steel piles, leading to net positive conservation credits determined by the Puget Sound Nearshore Habitat Conservation Calculator and a possible slight improvement in prey quality by reducing PAHs. However, SRKWs could be injured or disturbed by noise and sound pressure from the action as underwater sound from pile driving could exceed both behavioral and injury thresholds, causing whales to avoid the area, potentially temporarily reducing foraging, resting, and migrating. Criteria for monitoring are in place to stop work upon sightings of killer whales to ensure SRKWs do not experience the full intensity and duration of pile driving. Effects to salmon prey are not expected to be a source of harm for SRKWs and the project is not expected to further reduce forage for SRKWs.

Harmful algal blooms also occur in the Delta and, although toxic exposure of estuarine fish has been documented, the extent of their impacts to the aquatic food web is unknown (Lehman et al. 2010). More recently, concerns have been raised about ammonia levels in the Delta (Davis et al. 2018). The largest source of dissolved ammonium is the Sacramento Regional Wastewater Treatment Plant. Upgrades to the facility were completed in the spring of 2023, so that the facility will now remove 99 percent of ammonia and 89 percent of nitrogen from the wastewater. Within a few years, the upgrades will help to show how important ammonium ratios are in limiting diatom production in the Bay-Delta. The Central Valley Regional Water Quality Control Board is working with researchers at San Francisco State University and University of California, Davis, to evaluate the impact of ammonia in the Delta (Connon et al. 2011). All of the waters within the Delta are listed as impaired by at least one factor, either due to the presence of unacceptable levels of pollutants or lack of maintaining conditions such as adequate dissolved oxygen levels (EPA 2011a).

Pesticides are found in the water and bottom sediments throughout the Delta. The more persistent chlorinated hydrocarbon pesticides are consistently found at higher levels than the less persistent organophosphate compounds. Sediments in the western Delta have the highest pesticide content. Pesticides, such as polychlorinated biphenyls (PCBs), organochlorine pesticides, polycyclic aromatic hydrocarbons (PAHs), selenium, and mercury, among others, have concentrated in aquatic life, and have been documented at high levels in the Delta; but long-term effects and the effects of intermittent exposure are not known (Stewart et al. 2004, Leatherbarrow et al. 2005, Brooks et al. 2012). There are now concerns about the aquatic toxicity of pyrethroid-based pesticides (bifenthrin, cyfluthrin, cypermethrin, and permethrin), which have replaced organophosphorus pesticides such as diazinon and chlorpyrifos. Little is known about the potential for interactive toxicity from complex pesticide mixtures and/or pesticides interacting with other chemical, physical, or biological stressors (EPA 2011b). Pesticide use for the treatment and elimination of invasive aquatic vegetation may have important consequences for water quality parameters including: amount of light that reaches the water column, temperature, salinity, turbidity, and food availability, which may also influence the migratory paths that sDPS green sturgeon salmonids utilize in the Delta (National Marine Fisheries Service 2018e).

In December of 2018, the SWRCB updated the Bay-Delta Plan to protect beneficial uses in the Bay-Delta watershed. Phase I of this work involved updating San Joaquin River flow and southern Delta water quality requirements included in the Bay-Delta Plan (SWRCB 2018). The

EPA developed an action plan in 2012 to address water quality concerns in the Delta (EPA 2012). This plan included the following actions: (1) Strengthen estuarine habitat protection standards, (2) Advance regional water quality monitoring and assessment, (3) Accelerate water quality restoration through Total Maximum Daily Loads, (4) Strengthen selenium water quality criteria, (5) Prevent pesticide pollution, (6) Restore aquatic habitats while managing methylmercury, and (7) Support the Bay Delta Conservation Plan.

Adult salmonid exposure to contaminants within the Delta is limited and not likely to affect reproduction. However, survival and growth of juvenile salmonids will potentially be affected. In contrast, sDPS green sturgeon may remain in or return to the Delta at all life stages such that survival, growth, and reproduction are all important characteristics to consider for sDPS green sturgeon.

As described in the Status of the Species, SRKWs are vulnerable to the risks imposed by an oil spill. There is some level of risk from serious spills in the action area because of the heavy volume of shipping traffic and proximity to petroleum refining centers. The total volume of oil spills in inland waters of Washington has increased since 2013 and inspections of high-risk vessels have declined since 2009 (Washington State Department of Ecology 2017). The total volume of oil spills was less in 2017–2019 than in 2015–2017 but still higher than previous years (Washington State Department of Ecology 2019). In 2014, NOAA responded to 16 actual and potential oil spills in Washington and Oregon. PAHs, a component of oil (crude and refined) and motor exhaust, are a group of compounds known to be carcinogenic and mutagenic (Pashin and Bakhitova 1979). Exposure can occur through five known pathways: contact, adhesion, inhalation, dermal contact, direct ingestion, and ingestion through contaminated prey (Jarvela-Rosenberger et al. 2017), all of which could have adverse health effects to killer whales (see discussion in Section 4.9.3.5). In addition, oil spills have the potential to adversely impact habitat and prey populations, and, therefore, if they occur they may reduce prey availability for SRKWs.

In August 2022, a commercial fishing vessel sank off the west side of San Juan Island (in the action area) and an oil sheen was seen (see this NOAA News article[17]). Existing oil spill response plans were implemented and emergency ESA consultations were completed to minimize the impacts of response activities, including removing the vessel. The Wildlife Branch of the Incident Command monitored marine mammal sightings and activated a Killer Whale Deterrence Team to prevent exposure to the spill. SRKWs were not seen directly in the sheen.

In 2021, NMFS consulted on the reauthorization of the North Wing pier at the British Petroleum Cherry Point refinery (National Marine Fisheries Service 2021c). This biological opinion concluded that the action was likely to adversely affect but not likely to jeopardize the survival and recovery of SRKWs or adversely modify their critical habitat. The action does result in an incremental increase in risk of large oil spills. However, the oil spills most likely to occur would be substantially smaller in magnitude than the size likely to be catastrophic to SRKWs according to Lacy et al. (2017). Ongoing smaller spills are likely to continue but these are not expected to occur at a frequency or magnitude that would indirectly or directly expose SRKWs to acute toxicity or significantly affect toxin accumulation through prey.

[17]https://www.fisheries.noaa.gov/feature-story/coordinated-response-protected-southern-residents-sunken-ship-leaking-oil

6.16. Diversions and Entrainment

There are over 3,700 water diversions on the Sacramento and San Joaquin rivers, their tributaries, and in the Delta; most of these are unscreened (Mussen et al. 2013), posing a widespread threat to early life stages of fish. A study of 12 unscreened, small to moderate sized diversions (less than 150 cfs) in the Sacramento River, found that diversion entrainment was low for listed salmonids and sturgeon, though the study points out that the diversions used were all situated relatively deep in the river channel (Vogel 2013). The study also suggested that the factors affecting fish entrainment at unscreened diversions are complex and poorly understood because of the many site-specific variables that influence the exposure and vulnerability of fish to entrainment (Vogel 2013).

In a previous mark-recapture study addressing mortality caused by unscreened diversions, low mortality was observed in hatchery-produced juvenile Chinook salmon released upstream of four different diversions throughout the Sacramento River (less than or equal to 0.1 percent of individuals released, Hanson 2001).

The CVPIA's Anadromous Fish Screen Program was established in 1994 to minimize the impacts of diversions on anadromous fish and provide technical guidance and cost-share funding for fish screen projects. The Anadromous Fish Screen Program also supports activities and studies to assess the potential benefits of fish screening, determine the highest priority diversions for screening, improve the effectiveness and efficiency of fish screens, encourage the dissemination of information related to fish screening, and reduce the overall costs of fish screens (State Water Resources Control Board 2017b). Through the Anadromous Fish Screen Program, as of 2019, there were a total of 30 fish screens constructed at diversions on the Sacramento River, four fish screens in the San Joaquin and tributaries, and three fish screens at Delta diversions, which has resulted in reduced entrainment at those diversions. Currently, screen criteria for sDPS green sturgeon has not been developed (but see Verhille [2014]), and the benefits of projects intended to reduce salmonid impingement and entrainment at diversions to sDPS green sturgeon are not fully understood (National Marine Fisheries Service 2018e).

A NMFS biological opinion on the construction of NMFS-approved, state-of-the-art fish screens at the Tehama Colusa Canal diversion included a requirement to monitor, evaluate, and adaptively manage the new fish screens to ensure the screens are working properly and impacts to listed species are minimized (National Marine Fisheries Service 2009b). We expect these actions have helped reduce entrainment of listed fish in the Upper Sacramento River. In addition, the 2009 RPA included the requirement to identify and implement projects to ensure the municipal and industrial ranch water diversion is adequately screened to protect SR winter-run Chinook salmon, CV spring-run Chinook salmon, and CCV steelhead. A short-term screen is currently functioning at the site and a permanent screening option is under development.

Gate operations at the Red Bluff Diversion Dam (river kilometer 391, completed in 1964) created a migration barrier during a critical time for mature adults; operations limited access to spawning habitat for migrating spawning-capable adult sDPS green sturgeon (Poytress et al. 2015). In 2013, the Red Bluff Diversion Dam was decommissioned, which permanently lifted the gates and permitted volitional passage for sDPS green sturgeon during all months of river presence (National Marine Fisheries Service 2018e). This action has had a major beneficial

impact on spawning distribution for sDPS green sturgeon and possibly aided in population recovery (National Marine Fisheries Service 2018e).

6.17. Dredging and Vessel Traffic

Dredging operations periodically occur for a variety of purposes including the maintenance of shipping channels; maintenance of diversion intakes; and to remove accumulated sediments from recreational and commercial facilities such as boat docks and marinas. Dredging can have detrimental impacts to listed fish species through physical disturbance, and through the resuspension of sediment. ESA consultations are periodically conducted by NMFS for dredging projects of varying scope and scale in the Central Valley (National Marine Fisheries Service 2018a).

Select portions of the action area currently experience heavy commercial and recreational vessel traffic, creating hazards to listed fish species through both physical and acoustic disturbance. These impacts may lead to direct mortality or may induce changes in behavior that impair feeding, rearing, migration, and/or predator avoidance. The Stockton deep water ship channel and Sacramento deep water ship channel experience frequent large commercial vessel traffic. The mainstem Sacramento River, American River, Delta; and remainder of Suisun, San Pablo, and San Francisco bays receive occasional commercial tugboat traffic as construction barges and other heavy equipment are transported upstream. Finally, recreational vessel traffic occurs throughout the action area accounting for more than 6.4 million visitor-days annually (Healey et al. 2008). In a report on Delta boating needs through the year 2020, the California Department of Boating and Waterways stated an expected increase in boating activity in the Delta area (California Department of Boating and Waterways 2003).

Commercial shipping, cruise ships, and military, recreational, and fishing vessels occur in the inland and coastal range of SRKWs. Additional whale watching, ferry operations, and recreational and fishing vessel traffic occur in their inland range. The overall density of traffic is lower in coastal waters compared to inland waters of the Salish Sea. Several studies in inland waters of Washington State and British Columbia have linked vessel interactions with short-term behavioral changes in NRKW and SRKW (see review in Ferrara et al. [2017]), whereas there have been no studies that have examined interactions of vessels and SRKWs with behavioral changes in coastal waters. These studies that occurred in inland waters concluded that vessel traffic may affect foraging efficiency, communication, and/or energy expenditure through the physical presence of the vessels, underwater sound created by the vessels, or both. Collisions of killer whales with vessels are rare, but remain a potential source of serious injury and mortality, although the true effect of vessel collisions on mortality is unknown.

Vessel sounds in coastal waters are most likely from large ships, tankers and tugs, whereas vessel sounds in inland waters also come from whale watch platforms, ferry operations, and smaller recreational vessels. Commercial sonar systems designed for fish finding, depth sounding, and sub-bottom profiling are widely used on recreational and commercial vessels and are often characterized by high operating frequencies, low power, narrow beam patterns, and short pulse length (National Research Council 2003). Frequencies fall between 1 and 500 kilohertz (kHz), which is within the hearing range of some marine mammals including killer

whales and may have masking effects (i.e., sound that precludes or reduces the ability to detect and transmit biological signals used for communication and foraging).

Recently, there have been several studies that have characterized sound from ships and vessels as well as ambient noise levels in inland waters of the SRKW range (Bassett et al. 2012, McKenna et al. 2013, Houghton et al. 2015, Veirs et al. 2016, SMRU Consulting 2021). Bassett et al. (2012) assessed ambient noise levels in northern Admiralty Inlet (a waterway dominated by larger vessels). They found that vessel activity contributed most to the variability measured in the ambient noise, and that cargo ships contributed to the majority of the vessel noise budget. Veirs et al. (2016) estimated sound pressure levels for larger ships that transited through the Haro Strait, and found that the received levels were above background levels, and that underwater noise from ships extends up to high frequencies similar to noise from smaller boats. Commercial shipping was also identified as a significant source of low frequency ambient noise in the ocean, which has long-range propagation and therefore can be heard over long distances. Additionally, over the past few decades the contribution of shipping to ambient noise has increased by as much as 12 decibels (dB, Hildebrand 2009). Ship noise was identified as a concern because of its potential to interfere with SRKW communication, foraging, and navigation (Veirs et al. 2016). Echosounders used for navigation, commercial, and recreational fishing that use an 83 kHz signal, as well as those with a 200 kHz signal in deeper water, have emissions that extend outside of 400 meters (vessel approach distance used in Canada), which can create noise additions of 30 dB above ambient levels (Burnham et al. 2022). In a study that measured ambient sound in a natural setting, SRKWs increased their call amplitude in a 1:1 dB ratio with louder background noise, which corresponded to increased vessel counts (Holt et al. 2009). It should be noted that vessel speed also strongly predicts the whales' received sound levels from propeller and engine sound (Holt et al. 2017).

It is currently unclear if SRKWs experience noise loud enough to have more than a short-term behavioral response. As discussed in the Status of the Species, reduced time spent feeding and the resulting potential reduction in prey consumption is likely the most important pathway of effects due to vessels (Ferrara et al. 2017, Holt et al. 2021a, Holt et al. 2021b). Although the impacts of short-term behavioral changes, including ephemeral feeding disruptions, on population dynamics are unknown, it is likely that because SRKWs are exposed to vessels the majority of daylight hours they are in inland waters, and that the whales in general spend less time foraging in the presence of vessels, there may be biologically relevant effects at the individual or population-level (Ferrara et al. 2017). The extent of vessel impacts in coastal waters of SRKW critical habitat has not been studied and the density of vessels, particularly those targeting and following the whales for whale watching, is much less than inland waters.

Anthropogenic (human-generated) sound in the action area is generated by other sources beside vessels, including construction activities, and military operations. For example, Kuehne et al. (2020) reported measurements of underwater noise associated with military aircraft using a hydrophone deployed near a runway off Naval Air Station Whidbey Island, Washington. The average of the underwater received levels detected was 134 ± 3dB re 1 micropascal (μPa). The frequency of the sound from these overflights ranged from 20 hertz (Hz) to 30 kHz, with a peak between 200 Hz and 1 kHz. However, these peak levels are well below the best hearing sensitivity of the whales reported by Branstetter et al. (2017) to be between 20 and 60 kHz. Natural sounds in the marine environment include wind, waves, surf noise, precipitation,

thunder, and biological noise from other marine species. The intensity and persistence of certain sounds (both natural and anthropogenic) in the vicinity of marine mammals vary by time and location and have the potential to interfere with important biological functions (e.g., hearing, echolocation, communication), that may impact ability to access prey.

In-water construction activities are permitted by the USACE under Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act of 1899 and by the State of Washington under its Hydraulic Project Approval program. NMFS conducts ESA section 7 consultations on these permits and helps project applicants incorporate conservation measures to minimize or eliminate potential effects of in-water activities, such as pile driving, to marine mammals. Similarly, a recent consultation on 11 habitat-modifying projects in Puget Sound (National Marine Fisheries Service 2021f) stated, "criteria for monitoring and stop-work on sighting of SRKW is intended to ensure that SRKW will not experience duration or intensity of pile driving, either impact or vibratory, that would result in disturbance or harm to any individual of this species." Sound, such as sonar generated by military vessels also has the potential to disturb killer whales and mitigation including shut down procedures are used to reduce impacts.

6.18. Restoration Actions

Yolo Bypass Fish Passage Improvement

Reclamation and DWR have taken actions since 2009 to improve adult salmonid and sturgeon passage through the Yolo Bypass, including the Fremont Weir and other structures, by modifying or removing barriers. Actions completed to date include Wallace Weir Fish Rescue Facility and the Fremont Weir Adult Fish Passage Project. These actions in the Yolo Bypass have improved the migration corridor, reduced migratory delays and straying of adult salmonids and sturgeon, and helped minimize stranding in the Yolo Bypass. Improving access to the Yolo Bypass is also expected to benefit adult sDPS green sturgeon access to habitat (National Marine Fisheries Service 2018e).

Yolo Bypass Floodplain Inundation

Reclamation and DWR have taken actions to increase juvenile salmonid access to the Yolo Bypass and improve adult fish passage by constructing an operable gated structure in the Fremont Weir. The facility will be operated to increase the duration and frequency of Yolo bypass inundation from December through April, providing 17,000+ acres of enhanced floodplain habitat. The Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project was completed in 2024 and is expected to result in benefits to juvenile listed salmonids through increased growth and survival. Improving access to the Yolo Bypass is also expected to benefit sDPS green sturgeon juveniles (National Marine Fisheries Service 2018e).

Implementation of Pilot Reintroduction Program above Shasta Dam

In 2022, NMFS, the Winnemem Wintu Tribe, CDFW, and USFWS planned, implemented, and celebrated the return of endangered SR winter-run Chinook salmon to the McCloud River upstream of Shasta Reservoir for the first time since the construction of the Shasta Dam in the 1940s. The historic return of SR winter-run Chinook salmon eggs to the mountains upstream of

Shasta Reservoir was an urgent response to reduce the extinction risk during the third consecutive year of extreme drought, after near-year-class failures occurred in 2020 and 2021. The fertilized eggs were delivered to the McCloud River from the LSNFH and were placed into specialized incubators alongside the McCloud River's cold waters where the species once spawned.

After the eggs hatched and the fry were able to swim, the Winnemem Wintu Tribe and CDFW released the fish into the McCloud River, marking the first time that SR winter-run Chinook salmon had swum in that river in more than 80 years. Fish were collected at fish traps downstream from the egg incubation site, and then transported to the Sacramento River downstream of Shasta and Keswick dams to allow them to continue their journey to the Pacific Ocean.

The successful project in 2022 continued with improvements, additional partners, expanded science and monitoring, and further incorporation of indigenous knowledge in 2023 and 2024. It is the implementation of co-stewardship and co-management agreements signed by NMFS, CDFW, and the Winnemem Wintu Tribe in 2023 to formalize a shared commitment to restore traditional cultural fisheries including state and federally listed SR winter-run Chinook salmon to historical spawning grounds above Shasta Reservoir.

Engineering Solutions to Further Reduce Diversion of Emigrating Juvenile Salmonids to the Interior and Southern Delta, and Reduce Exposure to Central Valley Project and State Water Project Export Facilities (Including Georgiana Slough Non-Physical Barrier)

DWR and Reclamation have taken efforts to reduce juvenile salmon entry into the interior Delta to reduce at the export facilities. Work has been carried out in three phases consisting of multi-year studies. Phase I (2011–2013) included the formation of a technical working group consisting of representatives from DWR, CDFW, Reclamation, NMFS, and USFWS. An Initial Finding Report was prepared with a list of possible barrier locations to reduce salmonid entry into the interior Delta. Phase II (2012–2015) considered detailed evaluations, testing, and reporting on the options considered in Phase I. Locations considered include:

1. Georgiana Slough (Sacramento River)
2. Three-mile Slough (Sacramento River)
3. Head of Old River (San Joaquin River)
4. Turner Cut (San Joaquin River)
5. Columbia Cut (San Joaquin River)

Phase III is focused on implementation of a study project, titled the Salmon Protection Technology Study. The goal of Salmon Protection Technology Study is to construct and operate barriers at North Delta junctions along migratory reaches in the Delta with known lower migration survival. Its design included planning and conducting a diversion and salmon protection technology implementation program and evaluation in the Sacramento River using a Bio-Acoustic Fish Fence (BAFF), Floating Fish Guidance Structure, or Infrasound Fish Fence at locations that provide the largest resource benefit. Locations considered included Georgiana Slough, Steamboat Slough, and Sutter Slough. In 2023, DWR constructed a BAFF at Georgiana Slough. The BAFF is currently planned to be installed each year for 8 years, through 2030. In

each year of operation, DWR will conduct monitoring to assess the performance of the BAFF. DWR will monitor the effectiveness of the BAFF by acoustically-tagging and releasing up to 7,500 hatchery-reared juvenile late fall-run Chinook salmon and/or steelhead per year in the Delta Survival Study.

In November 2024, CDFW issued an ITP to DWR for the LTO of the SWP in the Delta (California Department of Fish and Wildlife 2024c). The ITP was developed in coordination with Reclamation, NMFS, CDFW, and DWR. It is based on DWR's November 2023 ITP Application and is in effect through November 1, 2034. The ITP covers five species protected under the California Endangered Species Act (CESA), including Delta smelt, longfin smelt, white sturgeon, SR winter-run Chinook salmon, and CV spring-run Chinook salmon. As with the previous permits, DWR focused on meeting the requirements of the CESA independent of the federal opinions. This allows for simpler processes for adaptively managing the system and ensuring CESA coverage remains in place independent of any future changes to the federal rules.

The new operating plan for the SWP includes a suite of actions and new science tools designed to reduce and offset impacts to listed species, including commitments to:

- Incorporate new genetic technology that allows real-time differentiation of listed salmonids from non-listed salmonids for real-time operational adjustments
- Complete tidal marsh and floodplain restoration projects that support spawning and rearing habitat for listed species
- Improve fish passage in critical migration corridors
- Support adaptive annual investments in salmon that are responsive to climate change stressors, including droughts
- Support hatchery production actions for listed species

The proposed operations also incorporate an AMP that will allow the SWP to incorporate new science to revise project components in a manner that more efficiently and effectively protects species.

The SWP element of the proposed action analyzed in the ITP is similar to Reclamation's 2024 proposed action, with a few exceptions. Importantly, the ITP covers the operation of the Georgiana Slough Salmonid Migratory Barrier (GSSMB). The GSSMB will be installed annually during the juvenile salmonid migration period to reduce the likelihood of emigrating salmonid entrainment in the Central and South Delta. The barrier was initially installed during the late spring–early winter of 2023 and demonstrated a high level of performance deterring juvenile salmonids from entering Georgiana Slough and maintaining their migration path along the Sacramento River. The continued operation of the GSSMB is expected to provide a higher probability of survival for emigrating juvenile salmonids that encounter the Sacramento River-Georgiana Slough junction and reduce entrainment of emigrating juvenile salmonids into the Central and South Delta and at the state and federal export facilities. The GSSMB will be evaluated through effectiveness monitoring as part of the AMP. Because this is a new project component, the routing benefits to salmonids has not been incorporated into the routing and survival modeling for Reclamation's proposed action.

This action is consistent with a priority 1 NMFS recovery action for SR winter-run Chinook salmon.

Restore Battle Creek for Sacramento River Winter-Run Chinook Salmon, Central Valley Spring-Run Chinook Salmon, and California Central Valley Steelhead

The Battle Creek Salmon and Steelhead Restoration Project is an ongoing project for the benefit of SR winter-run Chinook salmon, CV spring-run Chinook salmon, and CCV steelhead. This is also a Priority 1 NMFS recovery action (National Marine Fisheries Service 2014b). The project has been supported with federal, state, and private funding. As of 2019, implementation has included the following actions: (1) removal of the Wildcat Diversion Dam (fish passage barrier) on the North Fork Battle Creek; (2) construction of fish screens and ladders at two dams on North Fork Battle Creek; (3) construction of a fish barrier weir on Baldwin Creek to protect an upstream State trout hatchery; (4) construction of a 1-mile long bypass and tailrace connector to prevent the mixing of North Fork Battle Creek and South Fork Battle Creek waters; and (5) completion of designs for four dam removals, a fish screen and ladder, and a tailrace connector on South Fork Battle Creek.

Although full implementation has not yet occurred, benefits to listed salmonids in North Fork Battle Creek have already occurred and we expect further benefits to listed salmonids once completed. Since 2016, CDFW has been releasing SR winter-run Chinook salmon as part of the Battle Creek Winter-run Chinook Salmon Reintroduction Plan. The purpose of the Reintroduction Plan is to describe the issues, considerations, and steps necessary to reestablish a population of SR winter-run Chinook in North Fork Battle Creek, which will contribute to the recovery of the SR winter-run Chinook salmon. This Reintroduction Plan describes the process for reintroducing SR winter-run Chinook salmon to its historical spawning and rearing habitat in North Fork Battle Creek, assuming successful implementation of the Battle Creek Restoration Project. At the time the Reintroduction Plan was developed, an implementing agency had not been identified to carry out the plan. The USFWS subsequently agreed to take on responsibility for implementing the plan.

Other Restoration Actions

Specific smaller scale fish habitat restoration actions are occurring on the upper reaches of the Sacramento River between Keswick Dam and Red Bluff Diversion Dam as well as on the Lower American River between Nimbus Dam and the State Route 160 Bridge. At select sites within these areas, the projects involve creation of side channels, addition of spawning gravel, and placement of in-water woody material. NMFS has determined that actions that have been implemented have begun to contribute improvements to aquatic habitat, and are expected to continue to contribute to the recovery of ESA-listed salmonids in the Central Valley.

California EcoRestore is a California Natural Resources Agency initiative implemented in coordination with state and federal agencies to advance the restoration of at least 30,000 acres of Delta habitat. Driven by world-class science and guided by adaptive management, California EcoRestore will pursue habitat restoration projects with clearly defined goals, measurable objectives, and financial resources to help ensure success. The types of habitat and projects targeted include tidal wetlands, floodplain, upland, riparian, fish passage improvements and others.

Specific restoration targets include a focus on implementing a comprehensive suite of habitat restoration actions to support the long-term health of the Delta and its native fish and wildlife species. Specifically, the EcoRestore program aims to create 3,500 acres of managed wetlands created, 17,500 acres of floodplain restoration, 30,000 acres of Delta habitat restoration and protection, 9,000 acres of tidal and sub-tidal habitat restoration, and 1,000 acres of Proposition 1 and 1E funded restoration projects.

There have been a number of completed actions as part of EcoRestore (California EcoRestore 2020), and which have resulted in improved migration and rearing habitats for listed anadromous fish in the Lower Sacramento River and Delta. Completed actions include:

- Decker Island Tidal Habitat Restoration Project – Completed in 2018, this project restored 140 acres of tidal wetland habitat along the Sacramento River. This project will enhance habitat suitable for rearing salmonids, Delta smelt, and other native fish species. The project will increase the availability of primary productivity benefitting native fish within and adjacent to the restoration site. The project will also provide for habitat connectivity to the emergent tidal habitats for migrating salmonids.

- Dutch Slough Tidal Marsh Restoration Project – Located in the western Delta in Contra Costa County, the Dutch Slough project was completed in 2022 when 1,187 acres of land were converted to tidal marsh to provide habitat for salmon and other native fish and wildlife. This project is one of the Delta's largest restored freshwater tidal marshes. The tidal marsh is designed to create conditions that will favor native aquatic species over non-native fishes such as largemouth bass. Young salmon will be able to hide from predators in the marsh at high tide. Scientists expect that the tidal marsh will provide rearing habitat where the young salmon can grow strong before they journey to the ocean, boosting their survival rates.

- Tule Red Tidal Restoration Project – The Tule Red project was completed in 2019, restoring 420 acres of tidal habitat on the eastern edge of Grizzly Bay in the Suisun Marsh. The project was designed to create a self-sustaining tidal marsh intended to benefit listed fish and wildlife species, including Delta smelt, longfin smelt, and salmonids. The project is a collaboration between Westervelt Ecological Services, State and Federal Contractors Water Association, CDFW, and other resource agency partners.

- Winter Island Tidal Habitat Restoration Project – Completed in 2019, the Winter Island project restored unrestricted tidal activity to 589 acres of estuarine-rearing habitat near the confluence of the Sacramento and San Joaquin rivers. The ultimate goal of the project is to restore unrestricted tidal connectivity to the interior of Winter Island so as to create tidal wetland, associated high marsh, and riparian habitats. These habitats will in turn provide rearing benefits to native fish species. To achieve this goal, the project breached the perimeter levee to allow tidal hydrology access to the site. The Project consists of restoration planning, modeling, design, permitting, construction, and monitoring.

- Yolo-Flyway Farms Tidal Habitat Restoration Project – The Yolo-Flyway Farms Tidal Habitat Restoration Project was completed in 2018 when access to 359 acres of tidal freshwater and seasonal wetlands at the southern end of the Yolo Bypass was

reestablished. Situated in the northwestern Sacramento River Delta the project creates ecological conditions that generate food for Delta smelt in the Yolo Bypass Yolo County. The effort was the result of a partnership between DWR and a private landowner through a first-of-its-kind agreement. DWR has taken ownership of the site and is responsible for its long-term maintenance and upkeep.

- Lower Yolo Ranch Tidal Restoration Project – The Lower Yolo Ranch Tidal Restoration Project, which adjoins the Yolo Flyway Farms tidal marsh restoration, was completed through a partnership between DWR and Westlands to restore 1,682 acres of tidal marsh habitat. Located at the lower end of the Yolo Bypass, the accessible habitats provide for the benefit of Delta smelt and Chinook salmon and land-based threatened species such as the Swainson's Hawk and Giant Garter Snake. The design development and entitlement of the project was overseen by the multi-agency Fish Agency Strategy Team, which is tasked with approving mitigation for the ongoing need. The Lower Yolo Restoration Project is designed to take advantage of the large areas of the site that are at ideal elevations for tidal marsh restoration. These restored habitats are able to contribute to the food web of the Cache Slough Complex quickly and without large amounts of earthwork. Construction of the project was extremely efficient which began in August 2020 and was completed in October 2020.

- Knights Landing Outfall Gate – Located one-quarter mile from the confluence with the Sacramento River near Knights Landing, just below river mile 90, in Yolo County. This Fish Passage Restoration project is a positive fish barrier (with new concrete wing walls and installation of a metal picket weir) to serve primarily as a fish passage improvement action, preventing salmon entry into the Colusa Basin drain while also maintaining outflows and appropriate water surface elevations. The project was initiated because adult salmon may be able to enter the Colusa Basin drain through the Knights Landing outfall gates when certain flow velocities are met that attract migrating salmon. Once salmon enter the Colusa Basin drain, there is no upstream route for salmon to return to the Sacramento River and, absent fish rescue operations, the fish perish and are lost from production. Completion of the project has resulted in increased survival at this location, due to decreased entrainment. The project was completed in 2015 but in 2016 an operational failure at the Knights Landing outfall gate structure led to the collapse of the fish barrier.

- Lindsey Slough – Completed in 2014. The project consisted of (1) excavation and debris removal to enlarge an existing north embankment breach on Calhoun Cut at a northern arm of Lindsey Slough; (2) breaching of the south embankment of Calhoun Cut; (3) excavation of a 1-mile long channel at the historic southern arm of Lindsey Slough; (4) lowering of an existing earthen causeway on the historic channel; and (5) beneficial reuse of sediment excavated from the channel to create low habitat berms within the marsh and raise the remnant marsh site to a more mature marsh plain form. The project was implemented to restore habitat function and connectivity to Delta wetlands and waterways that had been degraded by the construction of dikes and culverts 100 years earlier. Completion of the project has restored habitat function and connectivity to 159 acres of freshwater emergent wetlands and 69 acres of alkali wetlands, and recreated and reconnected a 1-mile tidal channel.

- Sherman Island: Mayberry Farms – The Mayberry Farms Subsidence Reversal and Carbon Sequestration Project is a permanently flooded wetland on a 307-acre parcel on Sherman Island that is owned by the DWR. Completion of this project occurred in 2010, and has restored approximately 192 acres of emergent wetlands and enhanced approximately 115-acres of seasonally flooded wetlands.

- Sherman Island: Whale's Mouth – The Wetland Restoration Project is to restore approximately 600 acres of palustrine emergent wetlands, within an 877-acre project boundary, on a nearly 975-acre parcel of property on Sherman Island. Additional project goals include increasing stability and reduced seepage on a threatened section of levee; determining the rates/amounts of carbon sequestered for the project; determining the air and water quality impacts of the project; and providing recommendations for Delta-wide implementation. This project was initiated in 2013 and was completed in 2015.

- Sherman Island: Mayberry Slough – Tidal Marsh, Shaded Aquatic Riverine, and Upland Habitats Restoration Targets: 192 acres of emergent wetlands and 115 acres seasonally flooded wetlands. The DWR, in coordination with Reclamation District 341, constructed 6,100 linear feet of habitat setback levee to increase levee stability and provide waterside habitat restoration along Mayberry Slough on Sherman Island. This project was initiated in 2004 and was completed in 2009.

- Wallace Weir Fish Rescue Facility – The Wallace Weir is located at the downstream end of the Knights Landing ridge cut channel, which is an artificial channel constructed to control stormwater runoff and irrigation waters from the Colusa Basin drain into the Yolo Bypass. The Knights Landing ridge cut is operated in coordination with the Knights Landing outfall gates. The Knights Landing Ridge Cut has long been suspected to attract adult salmon that migrate upstream through the Yolo Bypass into the terminal of Colusa Basin. This is a terminal migration pathway and fish that enter the Colusa Basin are not able to return to the Sacramento River without intervention. Once salmon enter the Colusa Basin drain, there is no upstream route for anadromous fish to return to the Sacramento River, and the fish are unable to spawn and perish without reproducing. This loss represents a serious threat to anadromous fish populations, especially to SR winter-run Chinook salmon, whose small population size increases the impact of even small losses of individuals.

  In 2013, the CDFW and NMFS documented several hundred adult salmon in dead end agricultural ditches in the Colusa Basin Drain system, and while many of these fish were rescued from the drain, the stress from the poor water quality conditions prevented these salmon from successfully contributing to the reproductive population. The majority of the fish were determined to be SR winter-run Chinook salmon, although in subsequent years, staff from Reclamation District 108 and CDFW witnessed what were estimated to be thousands of fall-run Chinook salmon straying through the Knights Landing ridge cut into the Colusa Basin drain. CDFW and NMFS conducted an investigation to determine the migratory pathways that salmon followed into the Colusa Basin drain and determined that the Knights Landing ridge cut and the Knights Landing outfall gates were the most likely pathways. In response, the Wallace Weir Fish Rescue Facility was undertaken by Reclamation District 108 and others, as part of the SRSCs' Salmon Recovery Program, to

reduce the occurrence of adult straying through the Knights Landing ridge cut and into the Colusa Basin.

This project was completed in 2016, and includes replacing the seasonal earthen dam at Wallace Weir with a permanent, operable structure that would provide year-round operational control. The project also includes a fish rescue facility that would return special status migratory fish species back to the Sacramento River that are unable to pass volitionally over Wallace Weir. Wallace Weir has been treated as a common element to the larger habitat restoration and fish passage projects included as an RPA in the NMFS' 2009 Opinion. This project will serve primarily as a fish passage improvement action that will prevent upstream migration of straying adult salmonids and sturgeon into the Colusa Basin Drain and allow them to migrate upstream to reach their spawning habitats.

6.19. Consideration of Southern Resident Killer Whales

Most of the scientific research conducted on SRKWs occurs in inland and coastal waters of Washington State. In general, the primary objective of this research is population monitoring or data gathering for behavioral and ecological studies. Research activities are typically conducted between May and October in inland waters and can include aerial surveys, vessel surveys, close approaches, documentation, and biological sampling. Most of the authorized takes occur in inland waters, with a small portion in the coastal range of SRKWs. In light of the number of permits, associated takes, and research vessels and personnel present in the environment, repeated disturbance of individual killer whales is likely to occur in some instances. In recognition of the potential for disturbance and takes, NMFS took steps to limit repeated harassment and avoid unnecessary duplication of effort through conditions included in the permits requiring coordination among permit holders, such as restricting the number of research vessels within 200 yards of a SRKW at any given time. The aggregate effects of research activities were considered in a batched biological opinion for four research permits in 2012 (National Marine Fisheries Service 2012). The aggregate effects were also considered in the biological opinion on the renewal of the research permits (National Marine Fisheries Service 2018b). The opinion concluded the aggregate impacts of the scientific research projects were likely to adversely affect but were not likely to jeopardize the continued existence of SRKWs. The amount of prey available to SRKWs in the coastal portion of the action area is expected to be limited by other hydroelectric developments. NMFS completed consultations on the operation of the Klamath River water project from 2019 to 2024 and from 2024 to 2029, concluding that the proposed action in both consultations would reduce the amount of Klamath River fall-run Chinook salmon available as prey for SRKWs off the coast of California and Oregon through at least 2033 (National Marine Fisheries Service 2019a, 2024c).

6.20. Ongoing Habitat Restoration and Monitoring Actions

There are a number of habitat restoration actions in the action area, many of which are expected to continue to benefit listed fish. Some of the restoration actions are ongoing and require repeated annual implementation at a specific site or watershed (e.g., gravel augmentation below Keswick Dam). Others include program level commitments with detailed restoration actions to be determined at a later date (e.g., side channel restoration). One such program is the NOAA Restoration Center's Program to Facilitate Restoration Projects in the Central Valley (National

Marine Fisheries Service 2018c), which is expected to continue making improvements to aquatic and/or riparian habitat for listed fish. In 2021, NMFS consulted on the removal of four dams on the mainstem Klamath and associated activities, such as infrastructure modifications, removal, and reservoir drawdown, that impact Chinook salmon habitat (National Marine Fisheries Service 2021g). While temporary impacts to Chinook salmon are expected short-term habitat degradation, long-term benefits to the SRKW prey base are expected due to increased natural-origin Chinook salmon production and survival.

The proposed action includes restoration actions with annual implementation and are described as conservation measures in Table 4-6 of the ROC on LTO BA (U.S. Bureau of Reclamation 2019b). Some of these restoration actions have been consulted on previously such that their past and future beneficial effects to increase spawning and rearing habitat for listed salmonids are factored into the environmental baseline. Examples of previously consulted restoration actions include the Lower Clear Creek Habitat Restoration (National Marine Fisheries Service 2014c), Upper Sacramento River Restoration (National Marine Fisheries Service 2015d), and Lower American River Restoration (National Marine Fisheries Service 2015b), that are carried out under the CVPIA.

There are a number of ongoing monitoring and research efforts in the action area, which provide important information on listed anadromous fish. These include monitoring environmental conditions during action implementation (e.g., turbidity or temperature), monitoring fish presence, tagging fish for tracking distribution and survival, monitoring levels of impacts to fish and/or habitat, as examples. The effects of these monitoring and research activities are part of the environmental baseline because they previously have undergone ESA section 7 consultation either through individual or programmatic actions, ESA section 4(d), or section 10(a)(1)(A) incidental take permit. Similarly, any past monitoring that was associated with the NMFS' 2009 Opinion is also considered part of the environmental baseline.

6.21. Conservation/Mitigation Banks

A conservation bank is a market-based system developed to protect species and their habitats through a partnership between landowners, government agencies, and developers to allow landowners to sell "credits" to developers or other project proponents so as to offset the negative impacts of their projects. As such, there are a number of issues related to how conservation banks are treated in the environmental baseline section of a biological opinion as well as limits on how and when bank credits or in-lieu fees can be included in an Incidental Take Statement. The ecological value of the sold credits is part of the environmental baseline.

There are a number of conservation or mitigation banks with service areas that include the action area for the proposed action (described below). Conservation banks present a unique factual situation, and this warrants a particular approach as to how they are addressed in an ESA consultation. Specifically, when NMFS is consulting on a proposed action that includes conservation bank credit purchases, it is likely that physical restoration work at the bank site has already occurred and/or that an ESA section 7 consultation occurred at the time of bank establishment. A traditional interpretation of the "environmental baseline" might suggest that the overall ecological benefits of the conservation bank actions, therefore, belong in the baseline. Under this interpretation, all proposed actions, whether or not they included proposed credit

purchases, would benefit from the environmental "lift" of the entire conservation bank because it would be factored into the environmental baseline. In addition, where proposed actions did include credit purchases, it would not be possible to attribute their benefits to the proposed action, without double-counting. These consequences undermine the purposes of conservation banks and also do not reflect the unique circumstances under which they are established. Specifically, conservation banks are established based on the expectation of future credit purchases. In addition, credit purchases as part of a proposed action will also be the subject of a future ESA section 7 consultation. It is therefore appropriate to treat the beneficial effects of the bank as accruing incrementally at the time of specific credit purchases, not at the time of bank establishment or at the time of bank restoration work. Thus, for all projects within the service area of a conservation bank, only the benefits attributable to credits sold are relevant to the environmental baseline. Where a proposed action includes credit purchases, the benefits attributable to those credit purchases are considered in the effects of the action.

Liberty Island Native Fisheries Conservation Bank

Established in 2010, the Liberty Island Conservation Bank is a conservation bank that serves the Delta region. It is located in the southern Yolo Bypass in Yolo County, California. The Liberty Island Conservation Bank consists of 186 acres located on the still leveed northernmost tip of Liberty Island. Approved in July 2010 by the NMFS, USFWS, and CDFW, the Liberty Island Conservation Bank provides compensatory mitigation for permitted projects affecting special-status Delta fish species within the region. The Liberty Island Conservation Bank provides habitat for all Delta fish species including: SR winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, Delta smelt, and Central Valley fall- and late fall-run Chinook salmon. Of the 186 total acres, 139.11 acres can be used for salmonid conservation credits. The habitat includes tidally-influenced shallow freshwater habitat, shaded riparian aquatic habitat and Tule Marsh shaded riverine aquatic habitat. The increased ecological value of the enhanced rearing habitat for juvenile salmonids (and potentially sDPS green sturgeon), which have already been purchased, are part of the environmental baseline for the Project. Features of the bank are designated as critical habitat for CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon.

Fremont Landing Conservation Bank

Established in 2006, the Fremont Landing Conservation Bank is 100-acre floodplain site along the Sacramento River (Sacramento River mile 80) and is approved by NMFS to provide credits for impacts to SR winter-run Chinook salmon, CV spring-run Chinook salmon, and CCV steelhead. There are off-channel shaded aquatic habitat credits, riverine shaded aquatic habitat credits and floodplain credits available. Features of this bank are designated critical habitat for SR winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon.

Bullock Bend Mitigation Bank

Established in 2016, the Bullock Bend Mitigation Bank is a 119.65-acre floodplain site along the Sacramento River at the confluence of the Feather River (Sacramento River mile 106) and is approved by NMFS to provide credits for impacts to SR winter-run Chinook salmon, CV spring-

run Chinook salmon, and CCV steelhead. There are salmonid floodplain restoration, salmonid floodplain enhancement, and salmonid riparian forest credits available. Features of this bank are designated critical habitat for the SR winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon.

6.22. Importance of the Action Area for the Survival and Recovery

The action area defined for this proposed action includes PBFs of critical habitat designated for all species of NMFS ESA-listed species addressed in this opinion. For fish, these include spawning habitat that is critical for the natural production of these species; rearing habitat that is essential for growth and survival during early life stages and enhances overall productivity and population health; migratory corridors that facilitate anadromous life history strategies; and estuarine habitat that serves as additional rearing habitat and provides a gateway to marine phases of their lifecycle. For SRKW, these include: (1) water quality to support growth and development; (2) prey species of sufficient quantity, quality and availability to support individual growth, reproduction and development, as well as overall population growth; and (3) passage conditions to allow for migration, resting, and foraging.

The NMFS Recovery Plan for Central Valley salmonids (National Marine Fisheries Service 2014b) provides region-specific recovery criteria and recovery actions that were identified by NMFS in order to facilitate recovery of these species. Implementation of some of these actions has already begun and more are in the planning phase.

Recovery criteria for the SR winter-run Chinook salmon ESU identified in the Recovery Plan for Central Valley salmonids (National Marine Fisheries Service 2014b), includes three viable populations. The Recovery Plan further identified which populations/watersheds have the likely potential to become viable. These include the current population downstream of Keswick Dam on the Sacramento River, reintroducing a population to Battle Creek (tributary to the Sacramento River), and reintroducing a population to the Little Sacramento River or McCloud River upstream of Shasta Dam. As mentioned above, the only current population reproduces downstream from Shasta and Keswick Dams. Implementation of a "jump start" to the reintroduction plan to Battle Creek began in 2018. Reintroduction to McCloud River has been moving forward through pilot studies and phases of scientific investigations with important advances to study egg and juvenile growth and survival over the past 3 years.

Recovery criteria for the CV spring-run Chinook salmon ESU identified in the Recovery Plan for Central Valley salmonids (National Marine Fisheries Service 2014b), includes a total of nine viable populations, spread among four distinct geographical regions (or diversity groups). The Recovery Plan further identified which populations/watersheds have the likely potential to become viable. These include Clear Creek (in the Northwestern California Diversity Group); Battle Creek and one population upstream of Shasta Dam (in the Basalt and Porous Lava Diversity Group); Butte, Mill, and Deer creeks, as well as the upper Yuba River (in the Northern Sierra Nevada Diversity Group); and in the Southern Sierra Nevada Diversity Group, which includes the San Joaquin River below Friant Dam and one additional population above current impassible dams in either the Stanislaus or Tuolumne rivers. Currently, only three populations, all in the Northern Sierra Nevada Diversity Group, are considered to be both genetically independent and sufficiently high in abundance in most years to warrant "viable or close to

viable status." However, these three stronghold populations have been heavily affected by the recent years of drought, such that numbers of returning adults have been extremely low. Additionally, recent expansive and destructive timber fires in anadromous watersheds have left behind large amounts of ash, debris, mountainous bare terrain, and mixed stands of dead and scarred trees/vegetation. Resulting effects of fire can lead to local impacts and alteration of freshwater ecological function (Bisson et al. 2003, Bixby et al. 2015). Years of future impacts are expected associated with terrain devoid of vegetation, resulting in accelerated erosion/runoff, and physiochemical changes to soil/water chemistry (Johnson et al. 2012).

Recovery criteria for the CCV steelhead DPS identified in the Recovery Plan for Central Valley salmonids (National Marine Fisheries Service 2014b), include a total of nine viable populations, spread among four distinct geographical regions (or diversity groups). The Recovery Plan further identified which populations/watersheds have the likely potential to become viable. Most of the identified CCV steelhead populations are the same as CV spring-run Chinook salmon described above. Some differences include Antelope Creek instead of Butte Creek (for the Northern Sierra Nevada Diversity Group); and Calaveras River instead of the San Joaquin River. Currently, there is still a general lack of data on the status of wild populations. However, the catch of unmarked (wild) steelhead at Chipps Island has been less than 5 percent of the total smolt catch during recent years, which indicates that natural production of steelhead throughout the Central Valley remains at very low levels. Despite the positive trend on Clear Creek and encouraging signs from Mill Creek (both Core 1 Populations), concerns such as low adult abundances, loss and degradation of a large percentage of the historic spawning and rearing habitat, and domination of smolt production by hatchery fish still remain (National Marine Fisheries Service 2016b).

Recovery criteria for sDPS green sturgeon identified in the Recovery Plan for the Southern Distinct Population Segment of North American Green Sturgeon (National Marine Fisheries Service 2018e) include demographic recovery criteria (abundance, distribution, productivity, and diversity) and threat-based recovery criteria (significant known threats impeding recovery).

Recovery criteria for SRKW identified in the Recovery Plan for Southern Resident Killer Whales (National Marine Fisheries Service 2008d) include demographic recovery criteria (productivity, recruitment, survival, population age structure, and gender ratio).

7. EFFECTS OF THE ACTION

Under the ESA, "effects of the action" are all consequences to listed species or critical habitat caused by the proposed action, including the consequences of other activities that are caused by the proposed action but not part of the action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action (see 50 CFR 402.02).

7.1. Sacramento River Division

7.1.1. Effects of the Action on Species

Reclamation operates the CVP Shasta Division for flood control, navigation, agricultural water supplies, municipal and industrial water supplies, fish and wildlife, hydroelectric power

generation, Delta water quality, and water quality in the Upper Sacramento River. Water rights, contracts, and agreements specific to the Upper Sacramento River, or that may dictate conditions therein, include SWRCB Decisions 990, 90-5, 91-1, and 1641, Settlement Contracts, an Exchange Contract, and Water Service Contracts. Facilities include the Shasta Dam, Reservoir (4.552 MAF capacity), and Power Plant; Keswick Dam, Reservoir, and Power Plant; and the Shasta Temperature Control Device. The Shasta Division includes the Red Bluff Pumping Plant, the Corning Pumping Plant, and the Corning and Tehama-Colusa canals.

Figure 35 shows a map of the Sacramento River Division and Figure 36 depicts the deconstructed action describing how the proposed action components relate to each other. Table 16 identifies the primary stressors influenced by each proposed action component. Descriptions of each stressor, including how the stressors would affect an individual's fitness, are then discussed. The exposure and response of individuals and the proportion of the listed species population to the project-related stressors are then analyzed in the following sections for each proposed action component. As described in the Analytical Approach section, the analyses in this effects section reflect these relationships where we identify the potential impacts that proposed actions pose to listed individuals that are likely to be exposed to the effects of the actions. The subsequent integration and synthesis will then relate individuals' effects to identify risks or consequences to the proportion of populations represented by the individuals.

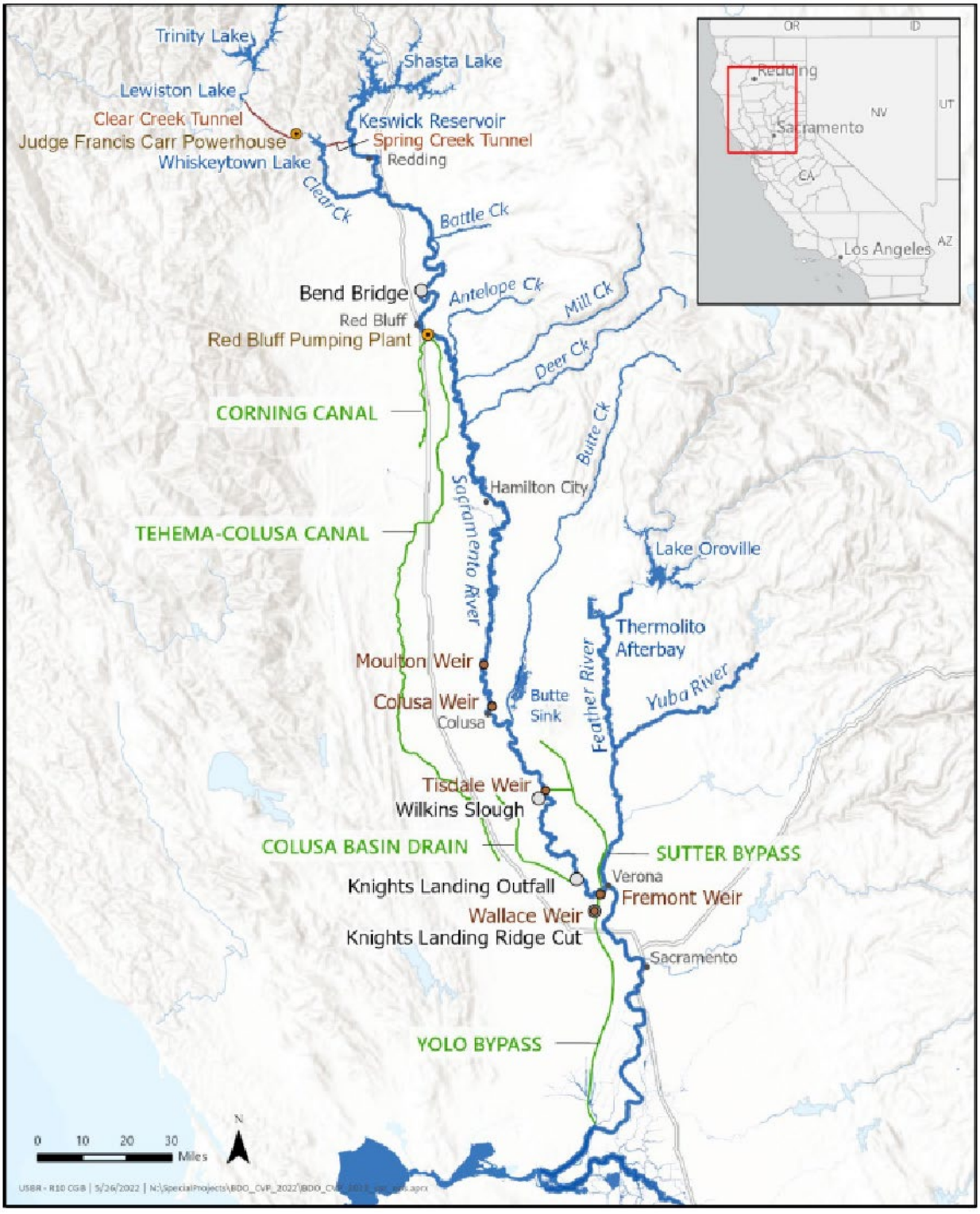


Figure 35. Sacramento River Facilities in the Shasta and Sacramento Divisions of the Central Valley Project and Flood Control Weirs and Bypasses.

Source: Figure 3-2, Section 3.1 in (U.S. Bureau of Reclamation 2023-2024)

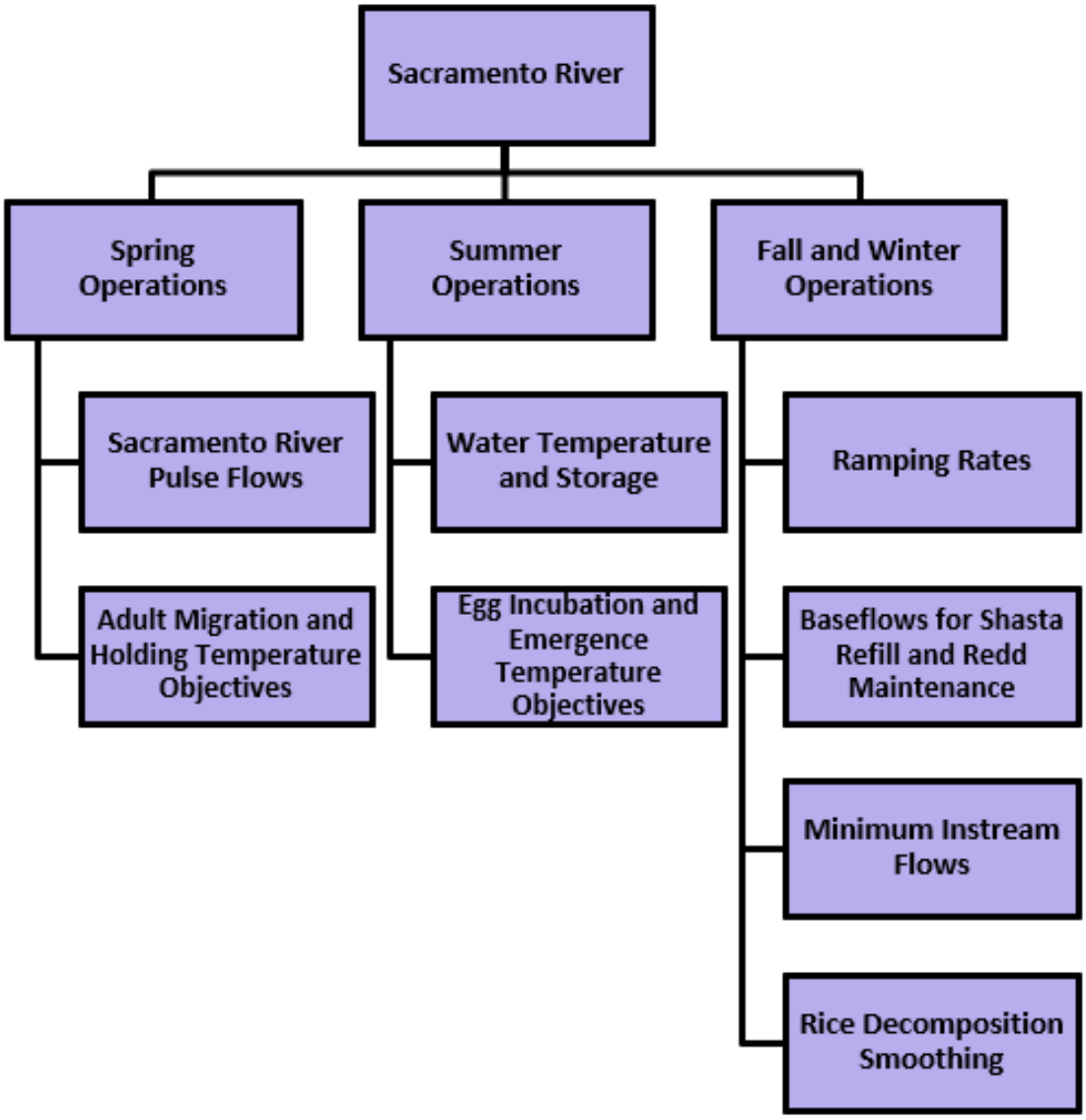


Figure 36. Deconstructed action describing the relation of project components in the Sacramento River.

Table 16. Primary stressors in the Sacramento River Division on Sacramento River winter-run Chinook salmon (WR), Central Valley spring-run Chinook salmon (SR), California Central Valley steelhead (SH), and green sturgeon (GS) influenced by each proposed action component categorized by seasonal operations.

	Stressors						
Action Component	**Water temperature and dissolved oxygen**	**Spawning habitat**	**Redd Quality**	**Stranding Risk and Redd Dewatering**	**Refuge habitat and Food availability and quality**	**Out-migration cues**	**Pathogens and Disease**
Fall and Winter Operations	WR, SR, SH	SR, SH	WR, SR	WR, SR, SH, GS	WR, SR, SH	WR, SR, SH	WR, SR, SH
Ramping Rates		SR, SH	WR, SR	WR, SR, SH	WR, SR, SH	WR, SR, SH	
Baseflows for Shasta Refill and Redd Maintenance, including Minimum Instream Flows	WR, SR, SH	SR, SH	WR, SR	WR, SR, SH	WR, SR, SH	WR, SR. SH	WR, SR, SH
Rice Decomposition Smoothing			WR	WR, SH	WR		
Spring Operations	WR, SR, SH	WR, SR, SH	WR, SR	WR, SR, SH	WR, SH	WR, SR	SR, SH
Sacramento River Pulse Flows						SR	
Adult Migration and Holding Temperature Objectives	WR						WR
Summer Operations	WR, SR, SH, GS	WR, SR	WR	WR, SR, SH	WR, SR, SH		WR, SR, SH
Water Temperature and Storage, Egg Incubation and Emergence Temperature Objectives	WR, SR, SH, GS	WR, SR	WR	WR, SR, SH	WR, SR, SH		WR, SR, SH

The sections below describe the specific seasonal components of the proposed action, their relation to the conceptual models describing species life histories, the effects of those proposed action components on identified stressors, and the subsequent effects to the species in the Sacramento River. In these subsequent sections, NMFS' goal is to trace how the proposed operations at Shasta Reservoir affect listed species downstream. We consider and analyze the proposed daily, monthly, and seasonal operational decisions to store or release water, operate the temperature control device, complete restoration actions, and integrate Shasta operations with those of the Delta and other reservoirs. Depending on the timing, location, life stage, and species affected, these effects can be beneficial, neutral, or negative, or all three based on which species is being evaluated. NMFS traces and analyzes these effects in this section of the opinion, often in a comparative analysis based on modeling outputs and historical data. These comparisons inform the context and the extent of the effects that are expected to result during the implementation of

the proposed action. Based on the modeling provided by Reclamation, the proposed action "Alternative 2 without VAs" (Alt2v1) is compared to the "Obligated Releases Scenario" (EXP3; see additional details in Appendix F: Modeling Section 1-1, CalSim 3, DSM2 and HEC5Q Modeling Simulations and Assumptions in U.S. Bureau of Reclamation 2023-2024) and in the Analytical Approach section of this opinion. The BA also presented effects determinations for many of the stressors, often for severity, proportion, frequency, and weight of evidence. These were considered and supplemented as necessary, and the differences were noted in some instances. NMFS determined the magnitude of the stressor by following the analytical approach previously described.

7.1.1.1. Conceptual Models and Stressor Linkages

To link proposed action components to the potential effects to the species and the species life stage, NMFS primarily uses the SAIL conceptual models (Windell et al. 2017), which describe the physical and biological drivers affecting the particular life stage and life stage transitions of SR winter-run Chinook salmon. The Sacramento River provides spawning, rearing, and migratory corridor habitat for SR winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon. Similar conceptual models can apply to all of the anadromous fish species. An additional and similar conceptual model tailored for sDPS green sturgeon (Heublein et al. 2017) was also incorporated.

With these models, NMFS is able to identify the proposed action components, the influence of those components on environmental drivers, and the habitat attributes and species response affected by changes in the environmental drivers. The environmental drivers and habitat attributes described by Windell et al. (2017) and Heublein et al. (2017) are also explicitly linked to the primary stressors affecting the species identified in the respective recovery plans (National Marine Fisheries Service 2014b, 2018f). Those stressors and their linkage to the recovery plan provide a reference for the severity of their effect on the species and how they may hinder or contribute to the recovery of the species.

For the Upper Sacramento River (Keswick Dam to Red Bluff Diversion Dam), the first SAIL conceptual model (CM1) defines the SR winter-run Chinook salmon egg incubation and alevin development stages as the duration of eggs in a redd to the emergence of fry (Windell et al. 2017). The hypothesized landscape attributes, environmental drivers, and habitat attributes affecting this life stage are described in Figure 37, where the stars indicate factors that are directly influenced by management actions. In this case, management actions are understood to influence Shasta and Trinity reservoir storage/hydrology, Keswick Dam releases/flow, in-river fishery/trampling, and substrate size. For the life stages described in CM1, the attribute and driver of Shasta and Trinity reservoir storage/hydrology and Keswick Dam releases likely contribute to the water temperature, flow conditions, spawning habitat availability, and predation stressors. The in-river fishery/trampling habitat attribute relates to the harvesting/angling impacts stressor, and the substrate size habitat attribute is a component of the spawning habitat availability stressor. Note that several river gauges are frequently referenced for temperature measurements in this reach. From upstream to downstream, they are: Sacramento River at Keswick (KWK), Sacramento River Upstream of Hwy 44 (SAC), Sacramento River Above Clear Creek (CCR), Sacramento River at Balls Ferry Bridge (BSF), Sacramento River at Jellys Ferry (JLF), and Sacramento River at Bend Bridge (BND).

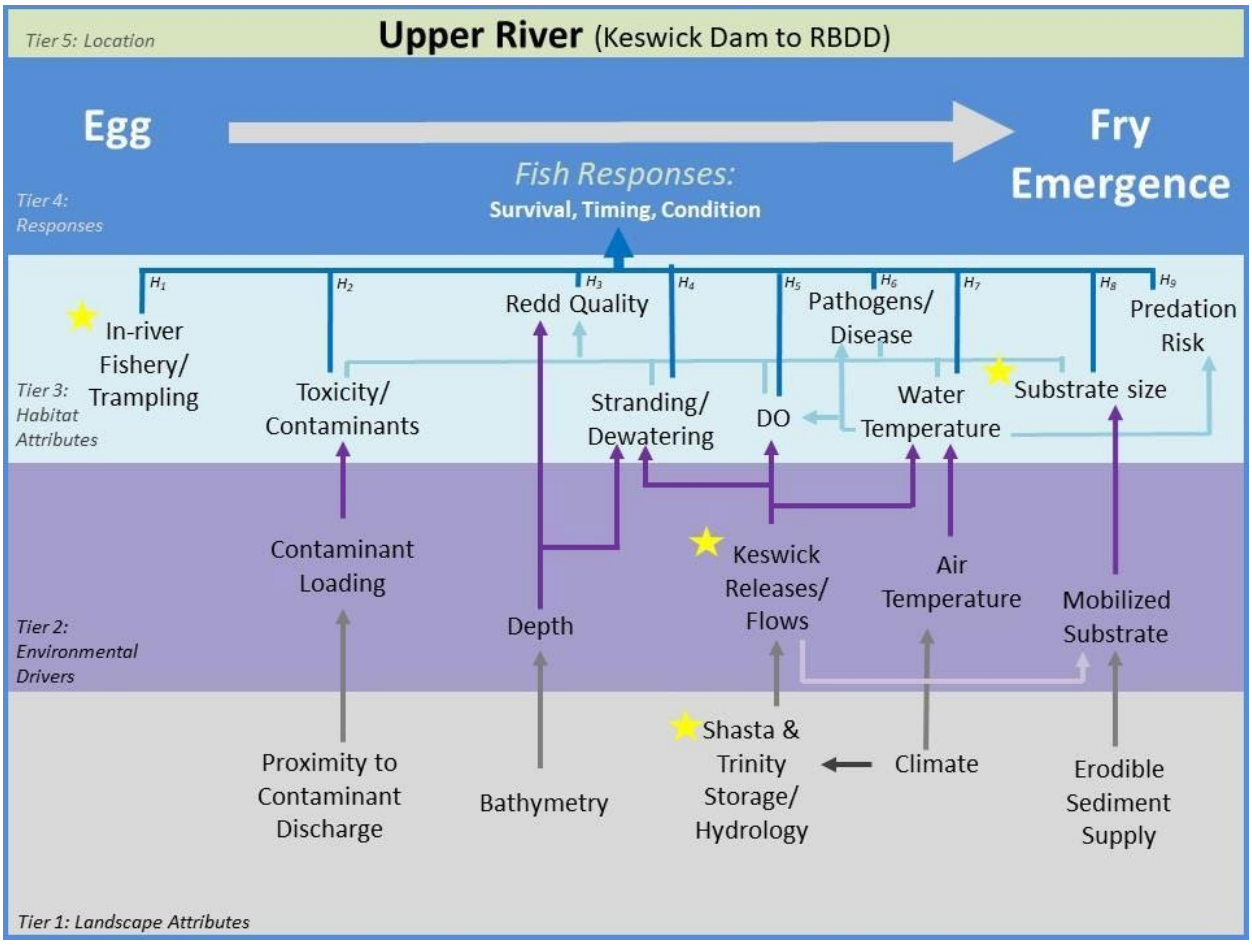


Figure 37. Conceptual model (CM1) of drivers affecting the transition of Sacramento River winter-run Chinook salmon from egg to fry emergence in the Upper Sacramento River. The stars indicate factors and pathways that are hypothesized to be influenced by management actions.

Source: (Windell et al. 2017)

Also applicable to the Upper Sacramento River (Keswick Dam to Red Bluff Diversion Dam), the second SAIL conceptual model (CM2) defines juvenile SR winter-run Chinook salmon rearing in this reach as the period from emergence as fry to juvenile migration past Red Bluff Diversion Dam (Windell et al. 2017). The hypothesized landscape attributes, environmental drivers, and habitat attributes affecting this life stage transition are described in Figure 38, with stars indicating factors and pathways hypothesized to be influenced by management actions. These include Shasta and Trinity reservoir storage/hydrology, contaminant loading, fish assemblages, Keswick Dam release/flows, and irrigation diversions. For the life stage described in CM2, the attribute and driver of Shasta and Trinity reservoir storage/hydrology and Keswick Dam releases likely contribute to the water temperature and flow conditions stressors affecting recovery.

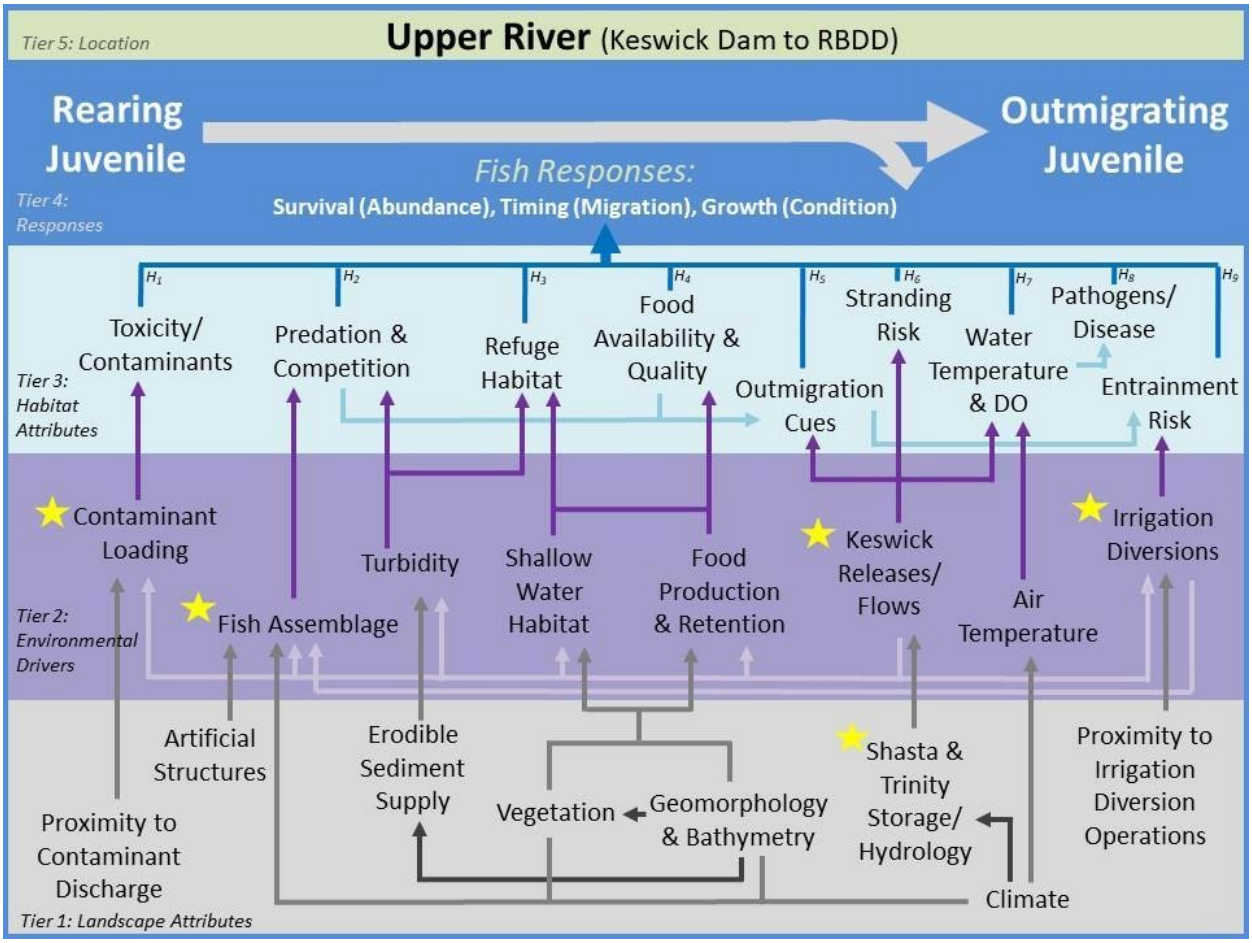


Figure 38. Conceptual model (CM2) of drivers affecting the transition of Sacramento River winter-run Chinook salmon from juvenile rearing to out-migration in the Upper Sacramento River. The stars indicate factors and pathways that are hypothesized to be influenced by management actions.

Source: (Windell et al. 2017)

The third SAIL conceptual model (CM3) defines juvenile SR winter-run Chinook salmon rearing in the middle Sacramento River (Red Bluff Diversion Dam to Sacramento, including Sutter and Yolo bypasses) as the period starting with juvenile migration past Red Bluff Diversion Dam until juveniles migrate past the I Street Bridge in Sacramento. The hypothesized landscape attributes, environmental drivers, and habitat attributes affecting this life stage transition are described in Figure 39. During this period, the factors and pathways hypothesized to be influenced by management actions include contaminant loading, fish assemblages, floodplain connectivity, flows/tributary reservoir releases, and water diversions/agricultural irrigation. For the life stage described in CM3, the attribute and driver of floodplain connectivity likely contributes to the loss of natural river morphology and function stressor affecting recovery. The driver of flows/tributary reservoir releases and water diversions/agricultural irrigation likely contribute to the passage impediments/barriers to migration and water temperature stressors affecting recovery.

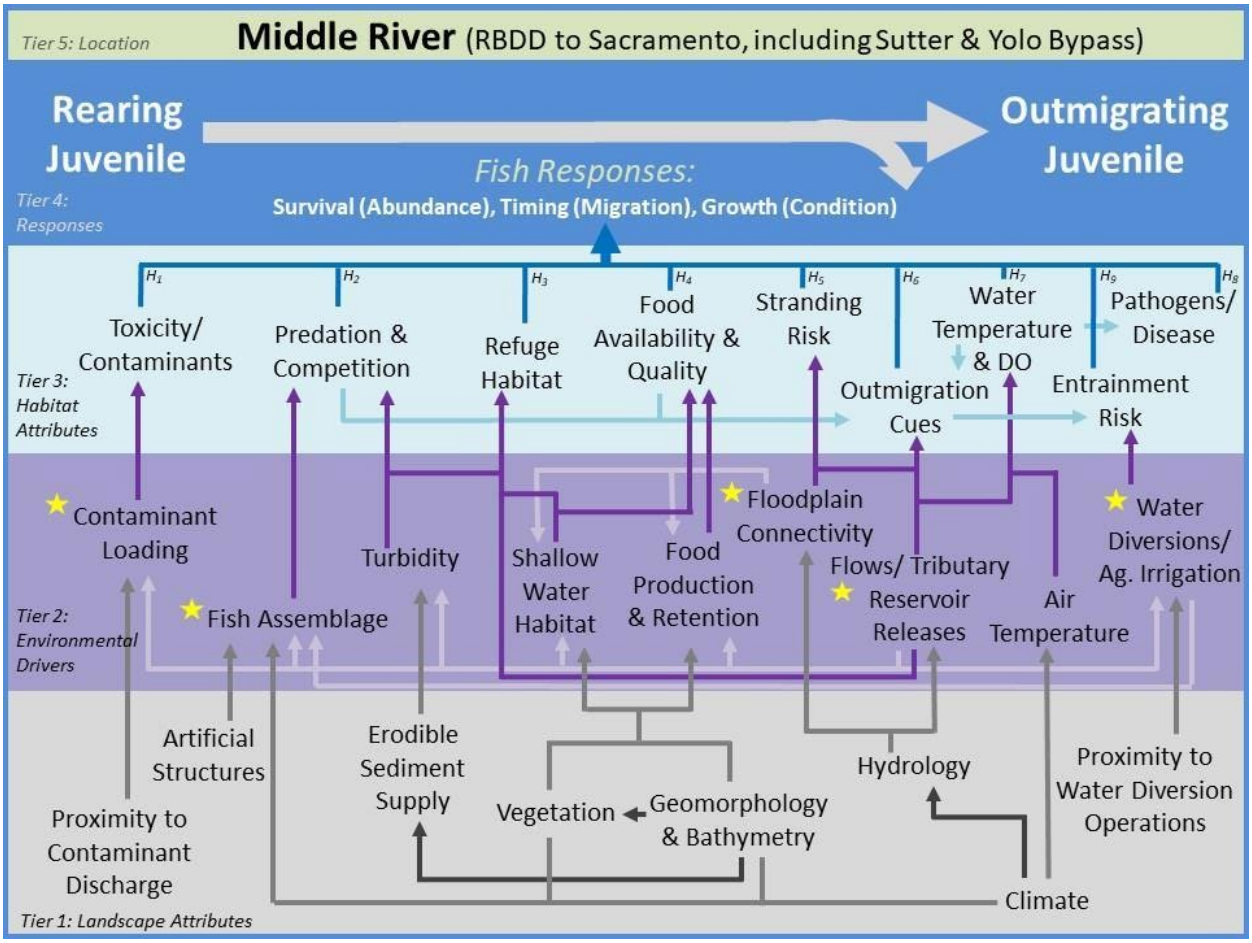


Figure 39. Conceptual model (CM3) of drivers affecting the transition of Sacramento River winter-run Chinook salmon from juvenile rearing to out-migration in the Middle Sacramento River. The stars indicate factors and pathways that are hypothesized to be influenced by management actions.

Source: (Windell et al. 2017)

The sixth SAIL conceptual model (CM6) defines adult SR winter-run Chinook salmon migration through the Sacramento River (San Francisco Bay to Keswick Dam) as the period starting with adult migration from the ocean to Keswick Dam in the Upper Sacramento River. The hypothesized landscape attributes, environmental drivers, and habitat attributes affecting this life stage transition are described in Figure 40. During this period, the factors and pathways hypothesized to be influenced by the management actions include flood bypass weirs, Shasta and Trinity reservoir storage/hydrology, in-river fishery/poaching, and Keswick Dam releases/Colusa Basin releases/flows. For the life stage described in CM6, the attributes and driver of Shasta and Trinity reservoir storage/hydrology, Flood Bypass Weirs, and Keswick Dam releases/Colusa Basin Releases/Flows likely contribute to the water temperature, flow conditions, and spawning habitat availability stressors affecting recovery. The in-river fishery/poaching habitat attribute relates to the harvesting/angling impacts stressor.

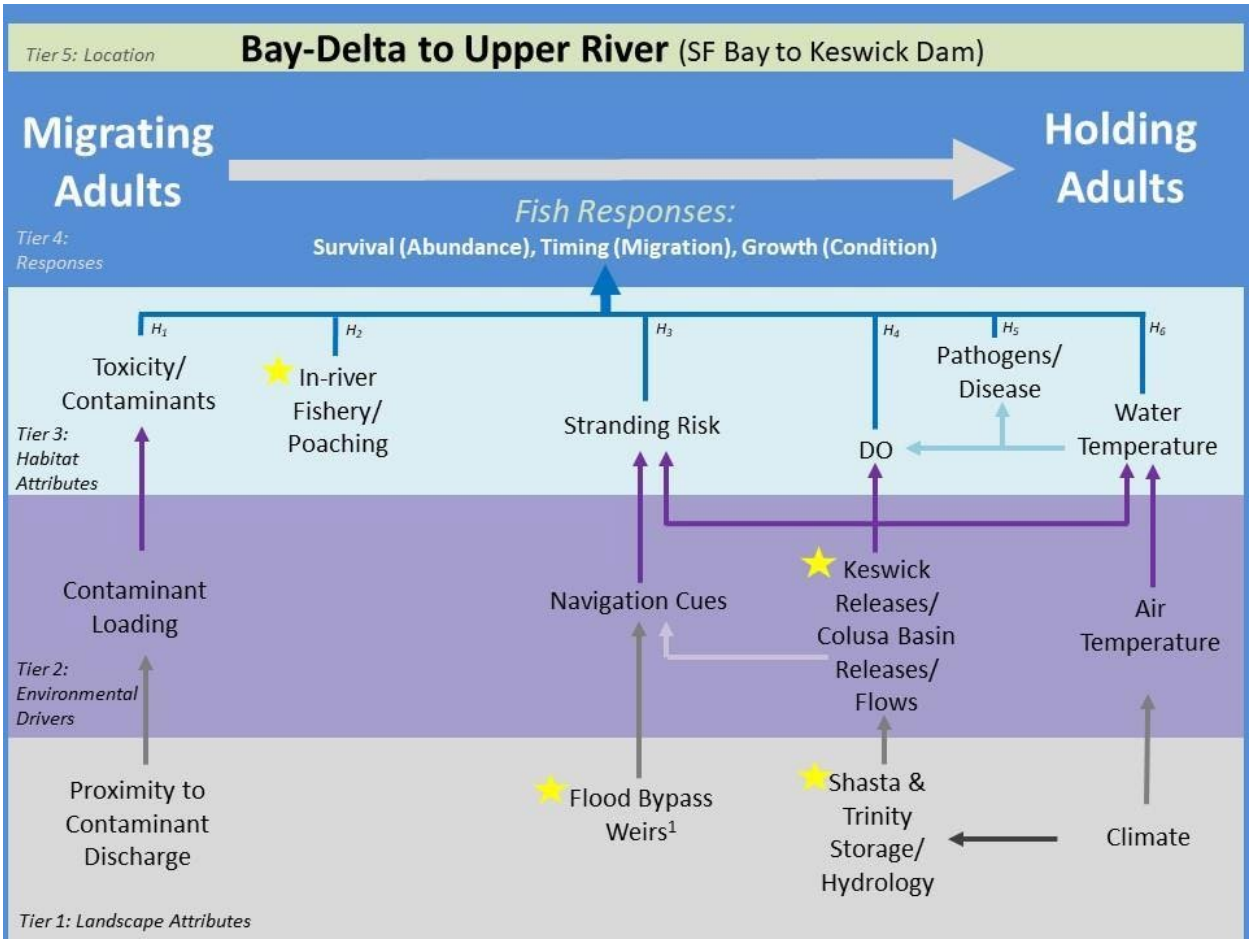


Figure 40. Conceptual model (CM6) of drivers affecting the transition of adult Sacramento River winter-run Chinook salmon from the ocean to the Upper Sacramento River. The stars indicate factors and pathways that are hypothesized to be influenced by management actions.

Source: (Windell et al. 2017)

The last SAIL conceptual model relevant to the Sacramento River Division (CM7) defines adult SR winter-run Chinook salmon holding to adult spawning in the Upper Sacramento River (Keswick Dam to Red Bluff Diversion Dam) as the period starting with adult migration past Red Bluff Diversion Dam until spawning. The hypothesized landscape attributes, environmental drivers, and habitat attributes affecting this life stage transition are described in Figure 41. During this period, the factors and pathways hypothesized to be influenced by management actions include the hatchery broodstock program, ACID Dam, Shasta and Trinity reservoir storage/hydrology, gravel quality and distribution/augmentation, Keswick Dam releases/cold water storage/flows, and in-river fishery/poaching. For the life stage described in CM7, the attributes and drivers of Shasta and Trinity reservoir storage/hydrology, temperature control device operations, and Keswick Dam Releases/Cold Water Storage/Flows likely contribute to the water temperature, flow conditions, and spawning habitat availability stressors affecting recovery. ACID and Gravel Quality and Distribution/Augmentation relate to spawning habitat availability, while the in-river fishery/poaching habitat and hatchery broodstock program attributes relate to the harvesting/angling impacts and hatchery effects stressors, respectively.

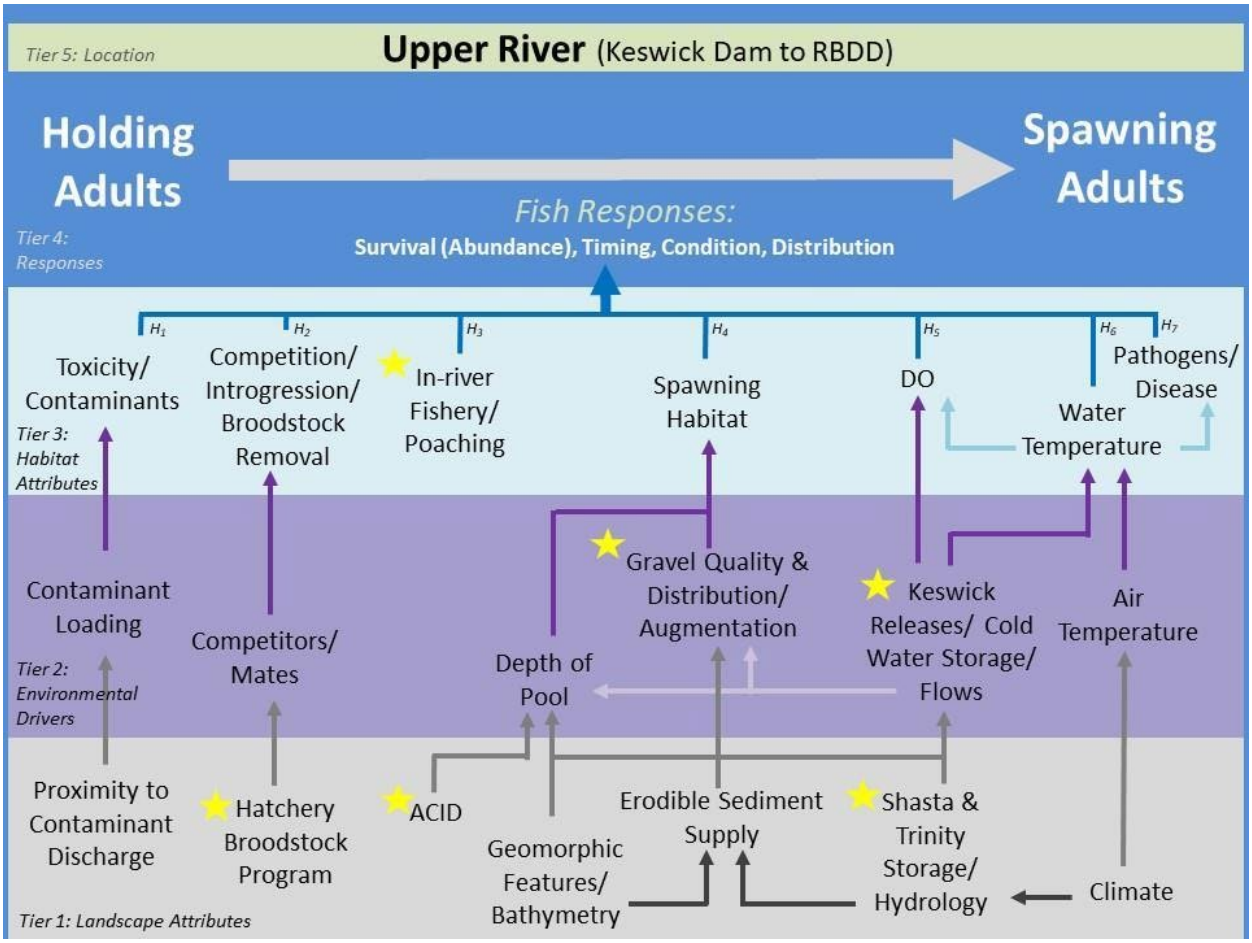
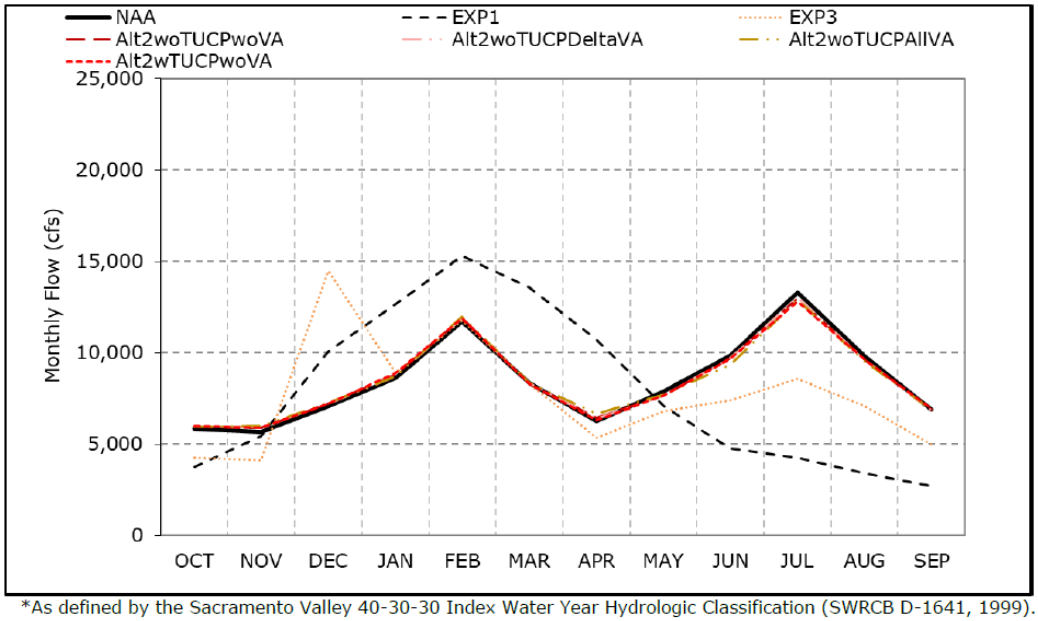


Figure 41. Conceptual model (CM7) of drivers affecting the transition of holding to spawning for adult Sacramento River winter-run Chinook salmon in the Upper Sacramento River. The stars indicate factors and pathways that are hypothesized to be influenced by management actions.

Source: (Windell et al. 2017)

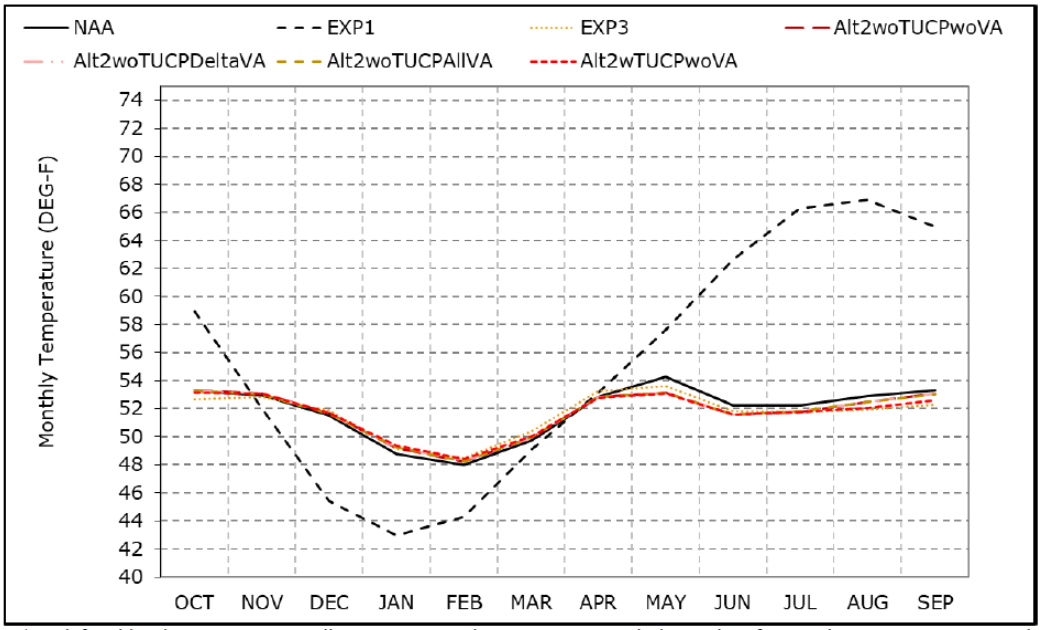
The BA includes modeling results for several operational scenarios; our analysis primarily uses results from the proposed action (Alt2v1) without TUCPs, the no action alternative (NAA), and EXP3. The pre-adoption period of the Delta VAs, which is a 2-year volumetric export reduction per the Voluntary Agreements (scenario: Alt2v2), has an initial 2-year time limit, and is not reasonably certain to occur for the duration of the proposed action. Analysis of the effects of the Alt2v2 scenario did not show substantial differences in flow and temperature for the Sacramento River Division, such that modeling results for all of the Alt2 scenarios are virtually indistinguishable outside of the Delta (see Figure 42 and Figure 43). The effects of the proposed action, commonly referred to as Alt2woTUCPwoVA in the model results for scenario Alt2v1, are analyzed in this effects analysis.



*As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).
*Water Year Types results are displayed with calendar year – year type sorting.
*All scenarios are simulated at 2022 Median climate condition and 15 cm sea level rise.

Figure 42. Sacramento River flow downstream of Keswick Reservoir, long-term average flow.

Source: Figure F.2.2-3-1 in (U.S. Bureau of Reclamation 2023-2024)



*As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).
*These results are displayed with calendar year - year type sorting.
*All scenarios are simulated at 2022 Median climate condition and 15 cm sea level rise.

Figure 43. Sacramento River below Keswick, long-term average temperature.

Source: Figure F.2.11-5-1 in (U.S. Bureau of Reclamation 2023-2024)

7.1.1.2. Sacramento River Division Project Components Analysis

7.1.1.2.1. Shasta Annual Operations

Reclamation operates Shasta and Keswick dams year-round in coordination with the other dams and reservoirs of the CVP and SWP. Seasonal operations follow a set of objectives. During the winter, Reclamation operates for flood control and building storage, considering the channel capacity within the Sacramento River and Shasta Reservoir flood conservation space. During flood control releases, Reclamation operates Shasta Dam to keep flows at Bend Bridge less than 100,000 cfs to protect populated areas downstream. This winter period can include significant flow fluctuations from Keswick Dam due to the flood control operations. During the winter and spring, when not operating for flood control, Shasta Dam is operated primarily to conserve storage while meeting minimum flows in the Sacramento River and to meet water quality and outflow requirements in the Delta. During the summer, Reclamation's operational considerations are mainly flows required for Delta outflows, instream demands (e.g., to meet contractual obligations to the SRSCs), upstream temperature control, and exports. Fall operations attempt to maintain temperature control and provide for fish spawning habitat. Except for diversions needed for rice decomposition, downstream irrigation demands typically decrease during the fall, so Reclamation manages operations to conserve storage and decrease Keswick releases during this time of year.

Reclamation largely manages Shasta operations through Governance, which includes three main coordination forums that will meet regularly to discuss seasonal and real-time operations. These include the Winter-run JPE SubTeam, Sacramento River Group (SRG), and the Shasta Operations Team (SHOT). The Winter-run JPE SubTeam is a technical group tasked with the development of the winter-run JPE each year and the winter-run broodstock assessment; it comprises technical staff from Reclamation, DWR, NMFS, USFWS, and CDFW. The SRG is a technical group to discuss pulse flow shaping, temperature management, fall flow smoothing, and fall/winter base flows. It comprises technical staff from Reclamation, DWR, NMFS, USFWS, CDFW, SRSCs, the Western Area Power Administration, SWRCB, and native tribes. The SHOT is a policy-level group that discusses the actions described in this proposed action when implementation may have biological, system conditions, or water supply impacts or tradeoffs. The SHOT comprises management and policy staff from key management agencies, including the SRSCs. Generally, topics will be discussed at a technical level through the SRG, with agency feedback provided prior to being discussed at the SHOT. For each specific seasonal action component, Reclamation will request NMFS, USFWS, and CDFW to provide technical assistance along with the other members through these groups. Governance describes that the groups will strive to reach a consensus; if a consensus cannot be reached, group members may elevate to the next higher level for resolution. Agency directors may reserve final decision-making for matters under their respective authority.

7.1.1.2.2. Shasta Fall and Winter Operations

Fall (October-November) operations are dominated by temperature control and the provision of adequate fish spawning habitat. By late fall, the remaining cold water pool in Shasta Reservoir is usually limited. This forces consideration of the operational tradeoffs of maintaining high flows in early fall; summer and fall spawning fish may construct redds at the edge of the river where

there is an increased likelihood of dewatering when flows are reduced. However, Reclamation is limited in reducing releases and building storage because early fall Sacramento River releases are still required to meet both the significant instream diversion demands between Keswick Dam and Wilkins Slough and SWRCB Delta requirements. This necessitates maintaining higher releases to support the instream demands until they decrease later in the season. After instream demands decrease, Reclamation's objective is to decrease Keswick releases to a lower level in order to conserve storage.

During winter, from December to February, Reclamation operates primarily for flood control and storage conservation, where the upper limit of operations is constrained by both the channel capacity within the Sacramento River and Shasta Reservoir flood conservation space. During this season and into the spring period, there are accretions (flows from unregulated creeks and other unmeasured sources) into the Sacramento River below Keswick Dam. These local accretions help meet both instream demands and outflow requirements, minimizing the need for additional releases from Shasta and Folsom reservoirs. In wetter year types, Reclamation may be able to operate primarily to target flood control and minimum instream requirements because of the large volumes of accretions in the Sacramento River. In drier years, these accretions may be lower and, therefore, require increased releases from the upstream reservoirs to meet state permit requirements and minimum health and safety exports in the Delta.

7.1.1.2.2.1. Ramping Rates

As described in Section 3.1.3 of the BA (U.S. Bureau of Reclamation 2023-2024), rapid changes in river elevation from ramping reservoir releases up or down can impact aquatic biota. Sudden flow decreases can strand fishes and macroinvertebrates. Ramping rates to limit how quickly releases are reduced can lessen or minimize these impacts. Under Water Rights Order 90-5, the change in the release rate (ramping) from Keswick Dam from September through February shall not decrease more than the following rates to minimize stranding of salmon:

- Releases shall not be decreased more than 15 percent in a 12-hour period.
- Releases shall not be decreased more than 2.5 percent in a 1-hour period.

In addition to the requirements under Order 90-5, the ramping rates for Keswick Dam between July 1 and March 31 would be reduced between sunset and sunrise.

- Keswick Dam releases greater than 6,000 cfs: reductions in releases may not exceed 15 percent per night, and no more than 2.5 percent per hour.
- Keswick Dam releases 4,000 cfs to 5,999 cfs: reductions in releases may not exceed 200 cfs per night, or 100 cfs per hour.
- Keswick Dam releases between 3,250 cfs and 3,999 cfs: reductions in releases may not exceed 100 cfs per night.

Reclamation, after coordination through the SHOT, may make deviations from this ramping rate to provide incremental benefits to fish species. The SRG will discuss such deviations prior to coordination through the SHOT.

Ramping rates during Fall and Winter Operations can be expected to impact the Stranding and Dewatering, Redd Quality and Out-Migration Cues stressors for SR winter-run Chinook salmon (as well as spawning habitat for non-listed fall-run Chinook salmon). While ramping rate restrictions are technically in effect from mid-summer to early spring, their primary impact is

during fall and winter. This is because the regulations are designed for that timeframe, and spring months (April-June) naturally have more stable water flows (minimum precipitation and reservoir inflow for the year is fairly certain). Therefore, they are analyzed as part of Fall and Winter Operations, where they are most relevant.

7.1.1.2.2.2. Baseflows for Shasta Refill and Redd Maintenance, Including Minimum Instream Flows

Reclamation proposes to set target base flows from Keswick Dam for the winter (December 1 through the end of February) based on Shasta Reservoir End of September (EOS) storage (the proposed action Component 3.1.4, Fall and Winter Baseflows for Shasta Refill and Redd Maintenance in U.S. Bureau of Reclamation 2023-2024). These base flows consider historical performance in building Shasta Reservoir's cold water pool. Table 17 provides Reclamation's expected Keswick releases based on Shasta Reservoir storage conditions. Fall and winter base flows support fall-run and CV spring-run Chinook salmon, address SR winter-run Chinook salmon redd dewatering stressors, and support cold water pool management.

Table 17. Keswick Dam December through February Default Release Schedule Determined by End-of-September Storage.

Shasta End-of-September Storage (million acre-feet)	Keswick Release (cubic feet per second)
≤ 2.4	3,250
≤ 2.8	4,000
≤ 3.2	4,500
> 3.2	5,000

Source: Table 3-1, Section 3.1 in (U.S. Bureau of Reclamation 2023-2024)

When considering the stressors caused by action components, winter releases would most likely affect the following stressors: Food availability and quality, Out-migration Cues, Pathogens and Disease, Redd Quality, Refuge Habitat, Spawning Habitat, Stranding and Dewatering, Water temperature and Dissolved Oxygen. There may also be direct effects to redds and rearing fish.

In years with the lowest Shasta storage at the end of September, Reclamation is expected to reduce flows to the greatest extent in the fall, winter, and spring to build storage. The lowest monthly long-term average flows downstream of Keswick Dam are about 6,000 cfs in the late fall (October and November) and again in the spring (April), compared to peaks of about 13,000 cfs in the summer (July; Appendix F, Figure F.2.2-3-1 Sacramento River flow downstream of Keswick Reservoir, long-term average flow in U.S. Bureau of Reclamation 2023-2024). In critical water years, the flows will be less than 6,000 cfs on average for the majority of the year (September through April), with only the summer months (May to August) experiencing relatively higher flows—which is largely the inverse of the unimpaired hydrograph (Appendix F, Figure F.2.2-3-6 in U.S. Bureau of Reclamation 2023-2024). These prolonged low flows of 3,250 cfs through the winter likely will have a negative effect on downstream migration of

juvenile salmonids. A recent assessment of mark-recapture survival models in the Sacramento River main stem revealed that of the numerous mortality factors considered, spanning multiple spatial scales, flow correlated most strongly with out-migration success (Iglesias et al. 2017). This assessment focused on hatchery-origin Chinook salmon, but it provides additional evidence that flow is one of the most important factors affecting overall survival of Chinook salmon in the Central Valley (Kjelson and Brandes 1989, Zeug et al. 2014, Michel et al. 2015). Likewise, a comparison of 2015 and 2016 tagging data that included both CV spring-run Chinook salmon and fall-run Chinook salmon showed faster migration times and higher survival correlated to the higher flow conditions in 2016 (Cordoleani et al. 2018). Overall, juvenile mortality during out-migration to the ocean is considered a critical phase to overall population dynamics (Williams 2006), and recent evidence suggests that SR winter-run Chinook salmon out-migration survival, and the conditions that affect it, are the primary drivers of smolt-to-adult ratio dynamics (Michel 2018). Recent conditions in the mainstem Sacramento River are such that a review of CWT recovery data for SR winter-run, late-fall-run, and fall-run Chinook salmon showed annual smolt-to-adult ratio estimates of less than 1 percent. For SR winter-run Chinook salmon, the mean smolt-to-adult ratio from 1999 to 2012 was 0.64 (standard error of 0.18). These levels are well below those defined for salmon populations to the north in the Columbia River basin. The Columbia River Basin Fish and Wildlife Program suggested a minimum of a 2 percent smolt-to-adult ratio required for population survival and 4 percent for population recovery for Upper Columbia River and Snake River Chinook salmon populations (Michel 2018). Therefore, while reducing reservoir releases helps build storage for the following temperature management season, doing so also has a negative effect on downstream migration and survival. The resultant winter flows (e.g., December) for the proposed action are expected to decrease the SR winter-run Chinook salmon smolt-to-adult ratio.

Reclamation also proposes an exception to the base flows described above to temporarily reduce Keswick Dam releases below 3,250 cfs to preserve storage, as long as flows at the SAC CDEC (California Data Exchange) gauge maintain a minimum 3,250 cfs throughout that Keswick Dam flow reduction. As described in Section 3.1.5 of the BA (U.S. Bureau of Reclamation 2023-2024), this exception will be undertaken after coordination through the SRG and SHOT.

7.1.1.2.2.3. Rice Decomposition Smoothing

Rice decomposition smoothing (see Section 3.1.6 of the BA, U.S. Bureau of Reclamation 2023-2024) could minimize impacts to both SR winter-run Chinook salmon and fall-run Chinook salmon by minimizing fry stranding and redd dewatering as flows drop in the winter. The SRSCs and CVP Water Service Contractors will synchronize their diversions to lower peak rice decomposition demand. Starting in August, Reclamation and the SRSCs, through the SRG, will develop a delivery schedule based on dewatering risk for SR winter-run Chinook salmon redd locations and update as conditions warrant.

7.1.1.2.2.4. Exposure and Response to Shasta Fall and Winter Operations

7.1.1.2.2.4.1. Sacramento River Winter-Run Chinook Salmon Exposure and Response

7.1.1.2.2.4.1.1. Stranding Risk and Dewatering

Stranding occurs when juvenile salmon are left isolated in shallow pools or on dry land due to rapid and substantial decreases in river flow below Keswick Dam. This phenomenon is primarily

caused by Keswick operations that alter the natural flow regime, leading to sudden drops in water levels. Key factors contributing to stranding include reservoir releases, inflows from other tributaries, channel morphology, and the behavior of juvenile salmon (particularly when they seek refuge in shallow areas or along the river margins, making them more vulnerable to stranding when water levels drop). Stranded fish are exposed to predators, direct sunlight, and thermal stress. Impacts can be mitigated by flow management (including ramping rates and implementing flow regimes that mimic natural patterns) and habitat management to restore habitat, identify stranding sites, and implement rescues in certain cases.

Before the end of October, most SR winter-run Chinook salmon fry will have emerged from their redds, and about half of the year's cohort of juveniles will have migrated past Red Bluff Diversion Dam. Rotary screw trap data from the last 10 years show that more than 50 percent of a brood year's cohort will have yet to migrate past Red Bluff Diversion Dam by October 1 (University of Washington Columbia Basin Research 2019). The species response to the conditions associated with Fall and Winter Refill and Redd Maintenance would be related to the Flow Conditions stressor, which include possible stranding, poorer feeding conditions, increased competition and predation related to less floodplain and side-channel habitat, and reduced emigration flows.

The stranding risk associated with changes in operations depends on the physical attributes of the habitat and the magnitude of the change in flow. Juvenile stranding generally results from reductions in flow that occur over short periods of time, and long-term planning tools cannot predict with certainty the level of effect of possible stranding on fish. The potential for juvenile stranding would also persist as operations continue to target lower reservoir releases in the fall and winter to maximize storage.

Stranded juveniles can die from desiccation, high temperatures, low dissolved oxygen, or higher levels of predation in habitats disconnected from the main channel after flow reductions. The Best Management Practices included in the proposed action are estimated to reduce the proportion of stranded juveniles by about one-quarter, specifically a 25-percent decrease in stranding across all water year types (from 10,934 under EXP3 to 8,224 under Alt2v1 [see Appendix L, Attachment L, Table X-4: "Potential Juvenile Stranding…," in Reclamation (2023-2024)]). However, there is also an expected 2-percent increase during critical years, which is a particularly vulnerable time for the population. The proposed action modeling scenario Alt2v1 reports that 8,224 juveniles are anticipated to be stranded averaged across all years, although there are biases in the modeling, which means this is likely an overestimate. For context, juvenile monitoring on the Upper Sacramento River for 9 recent years (2012–2013 to 2020–2021) observed stranding each year averaging a direct count of 1,382, with an average stranding removal estimate of 3,498 and average stranding totals estimated to be 4,375 (Table 15, Appendix L – Shasta Cold Water Pool Management in U.S. Bureau of Reclamation 2023-2024)

Considering this information, stranding risks are expected to persist with the implementation of the proposed action. The severity of the stressor is lethal given impacts of stranding on individual fish. The proportion of the population exposed is medium since before the end of October, about half of the year's cohort of juveniles will have migrated past Red Bluff Diversion Dam. The frequency of exposure is high due to its likely annual occurrence; the magnitude of effect is high given the impact to individuals is death; and the weight of evidence is high given the well-documented response of fish to quickly reduced flows.

Mortality of incubating eggs due to desiccation can also result from drops in river stage. Redd dewatering occurs when water levels drop below the depth of an existing redd. Consistent with past operations under the Sacramento River Temperature Task Group (SRTTG), it is defined here for salmon and CCV steelhead analysis as when the redd cap is exposed to air. There is about a 5-percent increase in the expected percentage of redds dewatered for SR winter-run Chinook salmon egg incubation in the Sacramento River from Keswick Dam to the Battle Creek confluence as a result of the Proposed Action (Table X-11, Appendix L – Shasta Cold Water Pool, Attachment L, Cold Water Pool Sacramento River Redd Dewatering in U.S. Bureau of Reclamation 2023-2024). In absolute terms, this would result, averaged across all years, in about 13 percent of SR winter-run Chinook salmon redds being dewatered (ranging from 7 percent in wet years to about 15 percent in critical years). However, the BA notes that "Estimates of redd dewatering are an order of magnitude greater than observed in recent years for all species. This bias likely results from the multiple counting of redd dewatering events […] Results are likely still useful for comparison between alternatives, but should not be considered as absolute values." From 2013–2021, anywhere from 0 to 28 shallow SR winter-run Chinook salmon redds were dewatered, ranging from 0 percent (2015, 2016, 2017) to 0.67 percent (in 2020) and averaging 0.13 percent of total redds (Table 18).

Table 18. Sacramento River winter-run Chinook salmon redd dewatering 2013–2020.

Brood Year	Sacramento River winter-run Chinook salmon redds dewatered	Minimum % redds dewatered out of estimated female escapement
2013	5	0.14%
2014	1	0.06%
2015	0	0.00%
2016	0	0.00%
2017	1	0.00%
2018	5	0.09%
2019	28	0.10%
2020	4	0.71%
2021	2	0.00%
2022	4	0.15%

Source: Table 17 in (U.S. Bureau of Reclamation 2023-2024) and Table 1 in (Gosselin and Beer 2024)

Stranding risk stresses individual SR winter-run Chinook salmon by causing physiological problems (e.g., lack of oxygen, temperature stress), increasing predation risk, and disrupting migration, ultimately impacting their survival and reproduction. The severity of the redd dewatering stressor is lethal, the proportion of the population exposed is small (since most eggs have emerged from their redds before the end of October), the frequency of exposure is high (annual), the magnitude of effect is medium, and the weight of evidence is high. The medium magnitude of the effect is the result of a lethal stressor, the small proportion of the population exposed, and the high frequency of exposure. The weight of evidence is high since redd dewatering of SR winter-run Chinook salmon on the Sacramento River is well monitored and documented, supported by multiple scientific and technical publications conducted on the species within the area of effect, including quantitative data, and/or modeled results.

The proposal to reduce flows at the KWK gauge below 3,250 cfs at certain points from December through February will rely on the accretion of storm flows over the four river miles downstream to the SAC gauge. This approach creates risks and will be difficult to implement accurately. Depending on the flow levels during rearing, there is a substantial stranding risk for juvenile Chinook salmon even at 3,250 cfs USFWS (2006), so reducing flows below this already low threshold would be expected to have negative impacts. Additionally, the SAC gauge is surrounded by an urbanized area, with impervious surfaces that create flashy runoff conditions. The proposed action suggests using "side flows from creeks within and around the City of Redding [which] may experience short term periods of high flows in response to major storm events" (U.S. Bureau of Reclamation 2023-2024). It may be difficult to implement such a real-time action, given uncertainty in gauge measurement, especially during periods of high flow (e.g., calibration may be required and access may be limited during storms). It may be infeasible to rapidly measure inflow from the catchment and adjust flows at Keswick Dam in real time, while not dropping flows at the SAC gauge below 3,250 cfs. Any errors in gauge readings could have sub-lethal effects and reduce out-migration survival, decrease downstream fish screen efficiency, cause stranding at restoration sites (both of which were engineered for a minimum 3,250 cfs flow), and increase toxicants from wastewater and stormwater discharges (the limits of which may be calculated based on the historic 3,250 cfs of available dilution). The impact of the proposed flows is likely to be moderate in magnitude since the proportion of the population exposed would be medium (for many years it is within the 95th percentile of passage of SR winter-run Chinook salmon juveniles at Red Bluff Diversion Dam) and the frequency of exposure is also medium (Reclamation has operated to 3,250 cfs flows at Keswick Dam at various points during the December to February in 13 of the past 30 years). Because these flow modifications have limited precedent in recent decades, there is some uncertainty about the precise extent of their effects, but based on the extensive monitoring of this river reach (e.g., acoustic tagging, rotary screw trapping, and stranding site monitoring), on balance, the weight of evidence is medium.

7.1.1.2.2.4.1.2. Out-Migration Cues

Storage of water in Shasta Reservoir during the winter will alter downstream flows and could hinder juveniles' out-migration cues, rates, and survival. Survival for SR winter-run Chinook salmon is variable, dependent primarily on flow, as well as habitat features and fish length (Hassrick et al. 2022). Acoustic tagging studies have shown variable survival for SR winter-run Chinook salmon released near Redding, California (about river mile 292) to Tower Bridge in Sacramento, California (river mile 59). However, if Yolo Bypass Weirs are overtopping during

migration, fish may have taken that route; therefore, these study estimates represent a minimum estimate of survival. Using Cormack-Jolly-Seber Models survival models studies initiated in January or February observed 35 percent survival in 2024, 12 percent in 2023, 13 percent in 2022, 98 percent in 2021, 94 percent in 2020, 39 percent in 2019, and 18 percent in 2018 (CalFish Track 2024).

Based on the Flow Threshold Salmon Survival Model, springtime (March 15 to June 15) juvenile out-migration survival in the mainstem Sacramento River (from the Deer Creek Confluence to the Feather River Confluence, as described in Michel et al. [2021]) is expected to be greatest in wet water years at 26 percent, and the least in critically dry water years at 11 percent. The other water years fall within this range, with survival decreasing in relatively drier water year types so that above-normal water years anticipate 21 percent survival, below-normal 16 percent, and dry 14 percent. Although the proposed operations are expected to increase survival 2 to 5 percent for springtime out-migration in relation to obligatory releases, depending on water year types (see Appendix J – Spring Delta Outflow Attachment J, Flow Threshold Salmon Survival, Table 2 in U.S. Bureau of Reclamation 2023-2024), most SR winter-run Chinook salmon will have already moved past Red Bluff Diversion Dam by March when a spring pulse flow historically has been implemented (Figure 44), and the flattening of the hydrograph in the preceding winter months (e.g., November to February) in order to store water for the rest of the year is expected to reduce juvenile SR winter-run Chinook salmon out-migration cues, rates and survival.

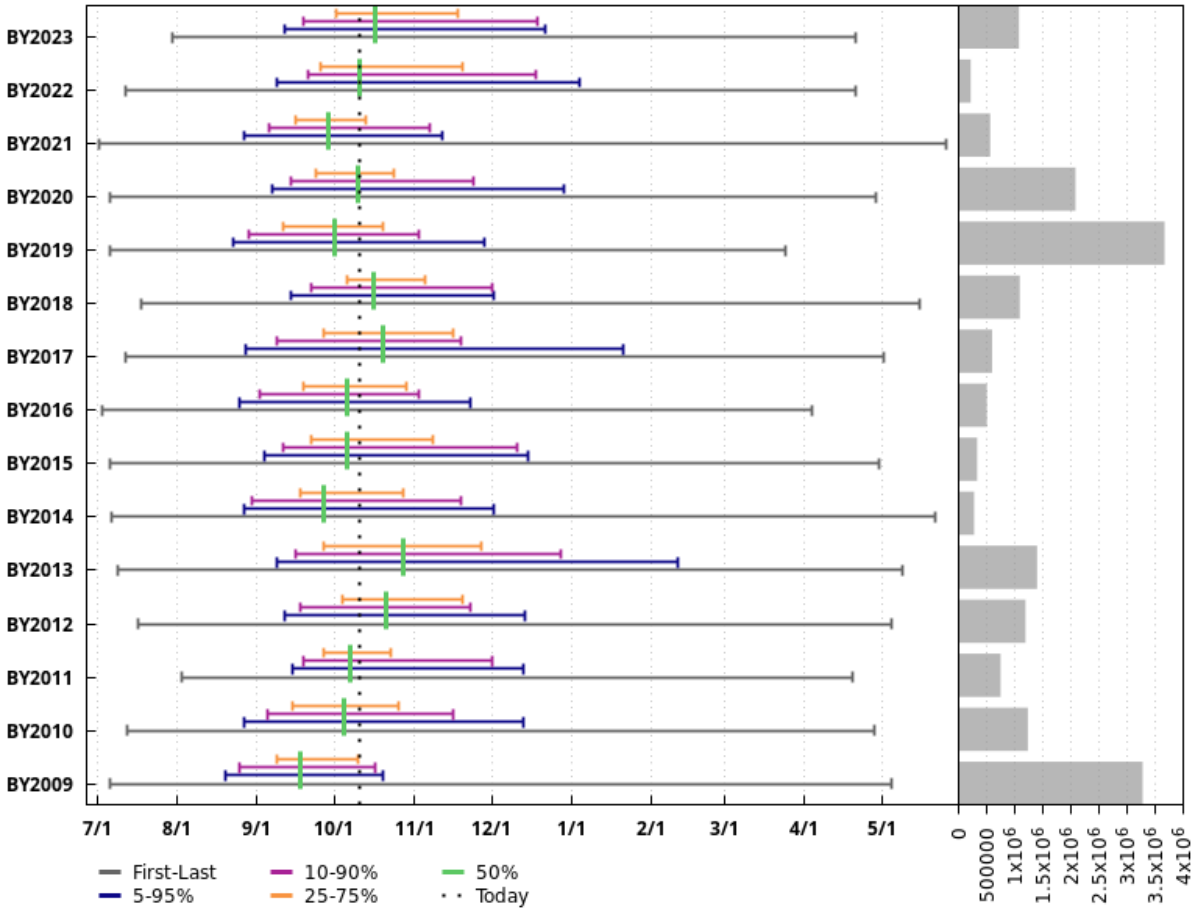


Figure 44. Migration timing, Brood Year 2009–2023, juvenile unclipped winter-run Chinook salmon, Red Bluff Diversion Dam, July 1 to June 30.

SacPAS (University of Washington Columbia Basin Research 2024b). Available from https://www.cbr.washington.edu/sacramento/cohort/

Additional modeling for the out-migration of Chinook salmon between Red Bluff Diversion Dam and the confluence of the Sacramento and American rivers showed minimal difference (within 1 percent) between the proposed action and EXP3 and minimal difference (within 2 percent) between water year types (Table 3, LTO Appendix J – Spring Delta Outflow Attachment J, XT Model in U.S. Bureau of Reclamation 2023-2024). Under the proposed action, the highest survival is predicted in wet years, 14.7 percent, followed by 14.0 percent in above-normal years, 13.3 percent in below-normal years, and the lowest in dry years, 12.9 percent. Generally, survival decreased in drier years, except the critical years were predicted to have a mean out-migration survival of 13.2 percent, marginally higher than dry years. Given these results, we consider that the severity of the out-migration cues stressor is lethal (by delaying out-migration), the proportion of the population exposed is medium (since out-migration timing is variable, from July through the following May), the frequency of exposure is low (as flows during the peak October time frame generally have low interannual variability and are inflated relative to natural flow), the magnitude of effect is high (the product of the aforementioned lethality, medium population proportion, and low frequency, following Table 5: Categories of

Effect Magnitude in the Analytical Approach section), and the weight of evidence is high (out-migration is monitored with rotary screw traps and acoustic tagging and is supported by multiple scientific and technical publications).

7.1.1.2.2.4.1.3. Water Temperature and Dissolved Oxygen

Proposed release and blending of water may alter the water temperature and dissolved oxygen, impacting juvenile metabolism and survival. Under the proposed action, the percent of months outside the 55.4°F to 68°F optimal water temperature range for juvenile SR winter-run Chinook salmon rearing and out-migration, for all years combined, July through December, is projected to be 93 percent of months at Keswick Dam, and 38 percent of months at Red Bluff Diversion Dam. The severity of the water temperature stressor is sub-lethal under the proposed action, as temperatures outside this range can hinder growth, smoltification and out-migration. The proportion of the population exposed is large since Keswick Dam discharge temperatures are the primary controlling factor in the reach where the SR winter-run Chinook salmon emerge, an area which has contracted upstream over time (now mostly above the CCR gauge, see Figure 45). Keswick Dam releases continue to be a factor as juveniles out-migrate (circa Wilkins Slough), although those releases can only mitigate downstream temperatures (which are more heavily driven by air temperatures) to a limited degree and during limited windows in the Spring and Fall (Daniels and Danner 2020, Michel et al. 2023).

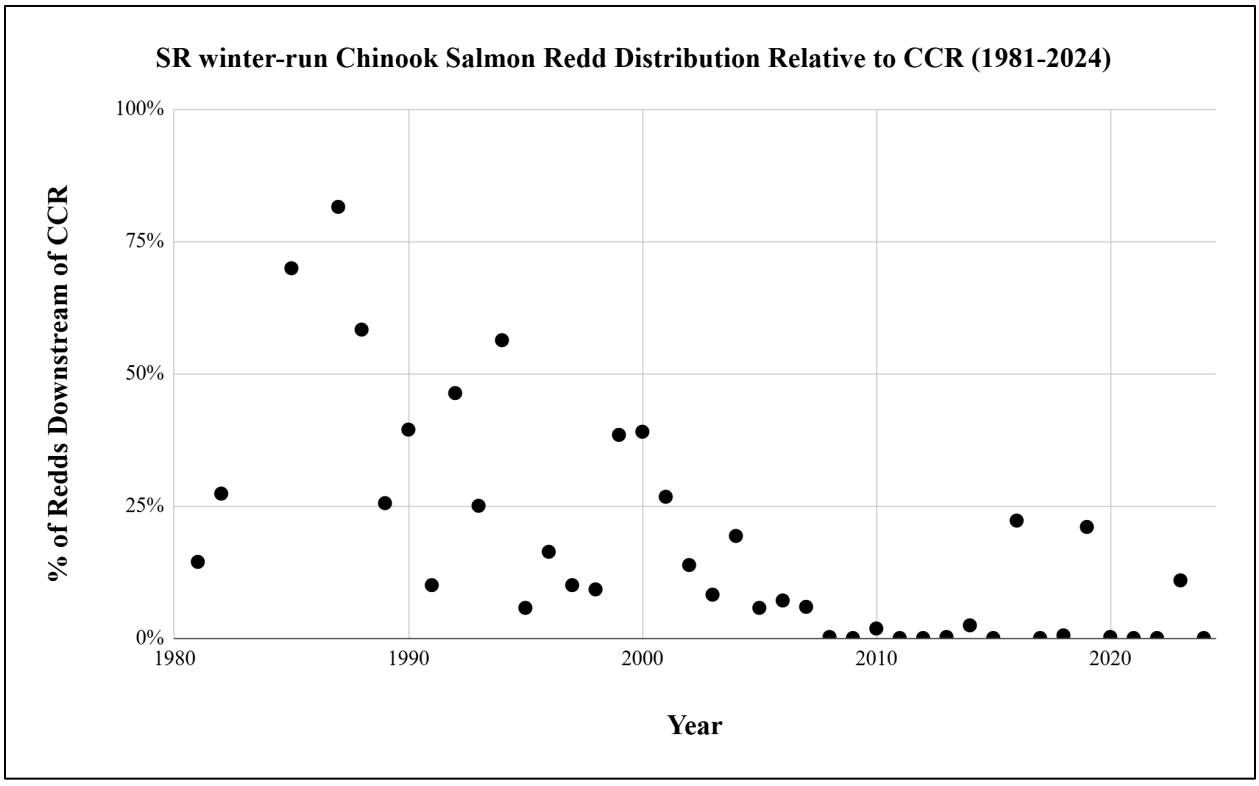


Figure 45. Percent of Sacramento River winter-run Chinook salmon redds downstream of the CCR CDEC station near Bonnyview Bridge. Note: no data available for three years (1983, 1984, and 1986).

Source: (California Department of Fish and Wildlife 2024b)

The frequency of exposure is high, as demonstrated by recent droughts (2007–2009, 2012–2016, and 2020–2022) that diminished the cold water pool in Shasta and resulted in warmer downstream water temperatures. The magnitude of effect is high, since temperature downstream at Wilkins Slough during out-migration can exceed the upper limit of the temperature range (68°F) through October, with daily averages up to 70.6°F (Figure 46). Temperatures in the 62°F to 68°F range decrease Chinook salmon juvenile growth, impair smoltification, and increase predation, while in the 68°F to 75°F range, they are less frequently found rearing (Carter 2005) and eventually die when exposed to temperatures around the 73°F to 79°F range for a week (EPA 2003). The weight of evidence is high since this reach of the Sacramento River has temperature gauges and fish monitoring to determine their exposure to this stressor.

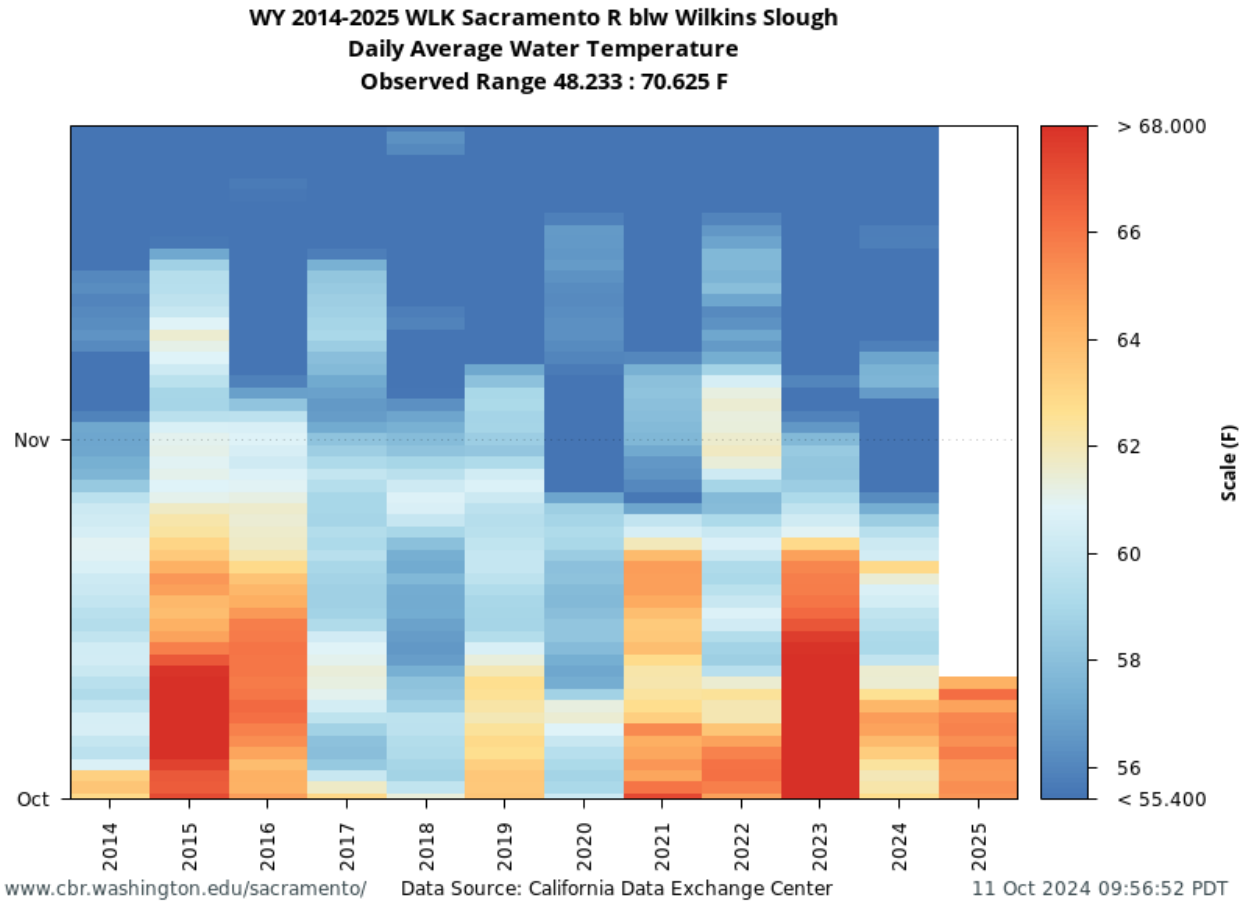


Figure 46. Water Year 2014–2025 WLK Sacramento River below Wilkins Slough daily average water temperature. Juvenile Sacramento River winter-run Chinook salmon rearing and out-migration is better in the 55.4°F to 68°F water temperature range, but the observed values are up to 70.6°F.

Source: (University of Washington Columbia Basin Research 2024b)

In addition to dissolved oxygen, heavy metal contamination and their effects are crucial to understand the well-being of SR winter-run Chinook salmon and the broader ecological community within their habitat. However, the specific impacts of CVP operations on these heavy metals remain poorly understood. The Sacramento River, particularly the reaches between Keswick Dam and Cottonwood Creek, contains levels of heavy metals toxic to aquatic life (the

Clean Water Act Section 303(d) List of Impaired Water Bodies), including cadmium, copper, and zinc (State Water Resources Control Board 2022). Additionally, Shasta Reservoir is listed for mercury contamination, raising concerns about the potential release of methylmercury through hypolimnetic discharges during dam operations. While the limnological effects of CVP operations on dissolved copper and oxygen demand are not well-documented, seasonal downstream exceedances of copper have been observed, possibly due to legacy pollution, ongoing sources, or reservoir operations (Sacramento River Temperature Task Group 2023). Further research is needed to fully understand the complex interactions between Shasta Division operations and water quality, and the impacts on SR winter-run Chinook salmon and other aquatic species.

7.1.1.2.2.4.1.4. Refuge Habitat and Food Availability and Quality

With relation to the stressors Refuge Habitat (i.e., riparian habitat for juvenile development and survival) and Food Availability and Quality, NMFS considers that the managed changes in the hydrograph can reduce access to riparian habitat and instream cover both in the immediate area of releases and further downstream (e.g., less frequent inundation of side channels). These changes can reduce accessibility to habitat that may support successful out-migration survival by providing rearing areas, refuge, or increased food availability.

During winter seasonal operations (from December 1 through the end of February), SR winter-run Chinook salmon fry have emerged from their redds and most juveniles will have migrated past Red Bluff Diversion Dam. Rotary screw trap data (University of Washington Columbia Basin Research 2019) from the last 10 years show that 5 to 10 percent of a brood year's cohort will have yet to migrate past Red Bluff Diversion Dam by December 1 (Figure 47), meaning there is limited potential exposure to the effects of the reduced flow conditions and reduction in access to riparian habitat due to loss of natural river morphology and function in the spawning area. Reducing flows during the juvenile rearing period (July–December) poses a stranding risk. The greatest impact posed by these operations would occur when December flows are potentially reduced to 3,250 cfs.

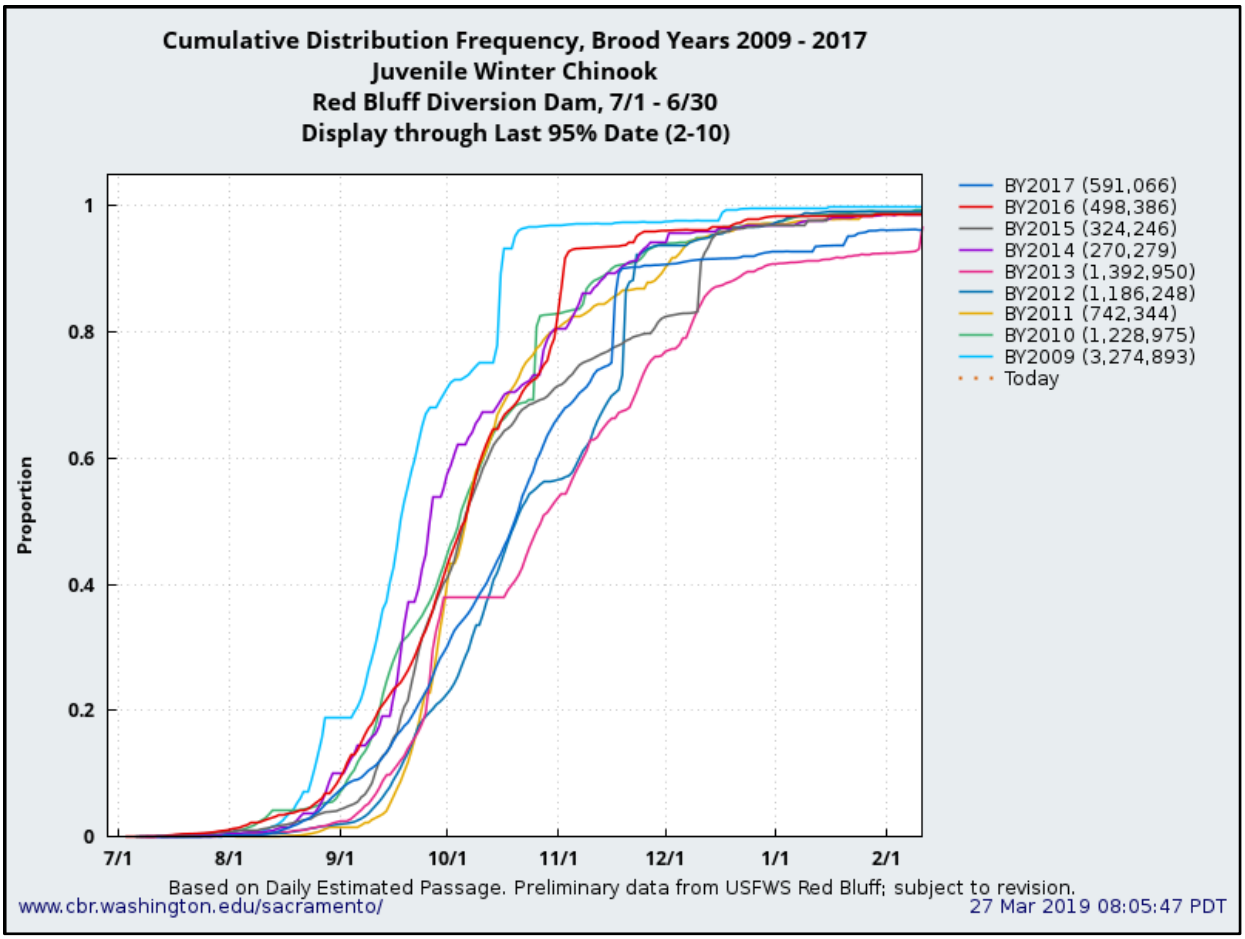


Figure 47. Red Bluff Diversion Dam Juvenile Sacramento River winter-run Chinook salmon passage data (2009–2017).

Source: (University of Washington Columbia Basin Research 2024b)

Sacramento River winter-run Chinook salmon rearing habitat was modeled using a weighted usable area (WUA) approach that produces a unitless habitat index based on the surface area of physical habitat available, weighted by suitability (flow velocities, depths, and substrate or cover; Payne 2003). The analysis in the Upper Sacramento River shows that for flows below 12,000 cfs, rearing habitat WUA value peaks at about 4,500 cfs for Reach 5 (Cow Creek to the ACID Dam). For Reaches 4 (Battle Creek to Cow Creek) and 6 (ACID to Keswick Dam) with the ACID Dam boards in or out, the habitat-flow relationship remains relatively static even with increasing flow. A relative decrease in WUA could result in either a reduced quality of rearing or force rearing fry and juveniles to move out of the habitat into less ideal conditions.

With relation to the stressors Loss of Riparian Habitat and Instream Cover, Loss of Natural River Morphology and Function, and Loss of Floodplain Habitat, NMFS considers that the proposed managed changes in the hydrograph are expected to reduce access to riparian habitat and instream cover in the immediate area of releases but perhaps more so further downstream (e.g., less frequent inundation of side channels, floodplains, and overtopping of flood system weirs into the Sutter and Yolo bypasses).

Under the proposed action, the expected WUA for SR winter-run Chinook salmon fry rearing in the Sacramento River from Keswick Dam to the Battle Creek confluence varies somewhat by water year, with the highest (about 260,000 WUA in critical water years) about 10 percent greater than the lowest (about 235,000 WUA in wet water years). The average WUA under the proposed action is nearly identical to the average under NAA, but there is a predicted 1 to 12 percent decrease (depending on water year type, with greater impact in wetter years) when comparing the proposed action to EXP3. Therefore, we expect some impacts to rearing habitat in some years (Appendix O - Tributary Habitat Attachment XX, Table X-7 in (U.S. Bureau of Reclamation 2023-2024). For refuge habitat, the severity of the stressor is sublethal, the proportion of the population exposed is large (since the single population of SR winter-run Chinook salmon rear in the Sacramento River watershed), the frequency of exposure is medium (with the decrease in rearing habitat contingent on water year type), the magnitude of effect is medium, and the weight of evidence is medium. For food availability and quality, the severity of the stressor is sublethal, the proportion of the population exposed is large (since the single population of SR winter-run Chinook salmon rear in the Sacramento River watershed, the frequency of exposure is medium (with lower impacts during the stressful, but infrequent, critical years), the magnitude of effect is medium, and the weight of evidence is medium.

7.1.1.2.2.4.2. Central Valley Spring-Run Chinook Salmon Exposure and Response

7.1.1.2.2.4.2.1. Water Temperature

Competition and hybridization with fall-run Chinook salmon, exacerbated by changes in river conditions due to Shasta and Keswick dams, have likely reduced the genetic integrity and reproductive success of natural-origin CV spring-run Chinook salmon (National Marine Fisheries Service 2014b). Current monitoring efforts struggle to differentiate between CV spring-run and fall-run Chinook salmon, resulting in uncertainty regarding the actual abundance of natural-origin CV spring-run Chinook salmon on the mainstem Sacramento River. The presence of hatchery-origin CV spring-run Chinook salmon further complicates the assessment of natural-origin fish. However, genetic analysis of hatchery fish and the observation of straying individuals indicate that some level of natural spawning may still occur in the Sacramento River (Killam 2022).

Cooler water temperatures may diminish the stress on adults holding and spawning in the Sacramento River, generally in deep pools downstream of Keswick Dam. However, the operation of the temperature control device to release warmer water and preserve the cold water pool for SR winter-run Chinook salmon during a drought may have sublethal effects. Under the proposed action, 6.6 percent of months will be outside the 42.1°F to 55°F optimal water temperature range for minimal adult CV spring-run Chinook salmon migration impairment averaged across all water years. In wet and above normal years, no months are predicted to be outside the aforementioned range. A medium impact is projected in below normal and dry years (about 3 to 5 percent of months outside the range). The impact is much greater during critical years, when about 30 percent of months are anticipated to be outside the aforementioned water temperature range. A large proportion of the population is exposed to the sub-lethal temperature stress since the Sacramento River is a central migratory corridor for CV spring-run Chinook salmon, but the frequency is low, since substantial impacts only occur during the driest years, resulting in a medium magnitude effect with a high weight of evidence.

For the egg incubation to fry emergence life stage, mortality of incubating eggs can occur due to increased metabolic demand and reduced dissolved oxygen in warmer water (i.e., temperature-dependent mortality). Central Valley spring-run Chinook salmon eggs incubate from September to February. The Shasta Framework is described at greater length in the Shasta Summer Operations section, but relevant to Fall and Winter operations, that component of the proposed action is generally expected to provide water temperatures of 53.5°F downstream from Keswick Dam that are consistent with temperature objectives for SR winter-run Chinook salmon. Although they are not specifically developed to meet the biological needs of CV spring-run Chinook salmon, depending on forecasted Spring and fall Storage metrics, the SR winter-run Chinook salmon objectives will provide water temperatures at or downstream from the CCR gauge through October 31, or at the CCR gauge, or at some point upstream of the CCR gauge. After October 31, temperatures may increase to levels that reduce egg survival depending on the remaining cold water storage in Shasta Reservoir and the influence of ambient air temperatures. We assume here that a small proportion of incubating CV spring-run Chinook salmon redds located downstream from the SR winter-run Chinook salmon temperature target locations and any redds downstream of Keswick Dam during the month of November would be exposed to lethal conditions.

Under the proposed action, the percent of months outside the optimal 55.4°F to 68°F water temperature range for successful yearling rearing of CV spring-run Chinook salmon for all years combined from April through December will be 94 percent at Keswick Dam and 27 percent at Red Bluff Diversion Dam. The proposed action will result in a 1 percent decrease in the percent of months outside the optimal water temperature range for successful yearling rearing at Keswick Dam, but this is offset by a 4 percent increase in temperatures outside this range, anticipated downstream at the Red Bluff Diversion Dam (Tables 20 and 21 in U.S. Bureau of Reclamation 2023-2024). The severity of the stressor is lethal, the proportion of the population exposed is small (since a larger proportion of rearing occurs on tributaries), the frequency of exposure is high (on average about 90 percent of months are outside the range), the magnitude of effect is high, and the weight of evidence is medium.

7.1.1.2.2.4.2.2. Pathogens and Disease

Wild Chinook salmon populations are susceptible to a variety of waterborne pathogens and encounter various microbial threats, including bacteria, protozoa, viruses, and parasites, in spawning grounds, rearing habitats, hatcheries, migratory corridors, and the marine environment (National Marine Fisheries Service 2023a). Pacific salmonids are susceptible to myxozoans, like *Ceratomyxa shasta*, *Parvicapsula minibicornis*, and *Tetracapsuloides bryosalmonae* (primarily targeting the digestive tract and kidneys of salmon, leading to organ failure), protozoan parasites, such as *Ichthyophthirius multifiliis* (causing skin and gill damage, impairing respiratory function), bacterial infections, like those caused by *Flavobacterium columnare* and *Renibacterium salmoninarum* (causing lesions and systemic disease) and viruses like Infectious Hematopoietic Necrosis (which can cause high mortality, particularly in juvenile salmon, due to hemorrhaging and abdominal distension; Lehman et al. 2020). Since the year 2000, the USFWS has monitored Central Valley salmonids for several of the aforementioned pathogens, specifically *P. minibicornis*, *T. bryosalmonae*, *C. shasta*, and Infectious Hematopoietic Necrosis virus (Lehman et al. 2020). Central Valley spring-run Chinook salmon populations may be susceptible to Infectious Hematopoietic Necrosis virus and bacterial kidney disease based on observations of these diseases in hatchery-reared conspecifics (National Marine Fisheries Service

2022a). The occurrence of pathogen virulence is diminished in cooler waters, and in some cases, changes in flows can disrupt the complex life cycle of the parasites.

The proposed action is expected to exceed temperature thresholds that increase pathogen virulence in 17 percent of months at Keswick Dam, and 59 percent of months at Red Bluff Diversion Dam in critical water years above the 59.9°F pathogen virulence water temperature threshold for adult CV spring-run Chinook salmon migration, at the KWK gauge, April through October (Tables 11 and 12 of Section 6.2.2.3 in U.S. Bureau of Reclamation 2023-2024). In relation to Reclamation's non-discretionary releases, this is a 12 percent increase during critical years. The severity of the stressor is sublethal, the proportion of the population exposed is large (the Sacramento River is a central migratory corridor for adults), the frequency of exposure is high (with impacts at Red Bluff Diversion Dam in all water year types, ranging for about 13 to 59 percent), the magnitude of effect is high, and the weight of evidence is medium.

7.1.1.2.2.4.2.3. Spawning Habitat, Stranding, and Dewatering

By mid-October, close to 100 percent of CV spring-run Chinook salmon will have completed spawning in the upper reaches of the Sacramento River (Vogel and Marine 1991). The species response to fall flows that are reduced to 3,250 cfs in the Upper Sacramento River would include redd dewatering, stranding, poorer feeding conditions, increased competition and predation related to less floodplain and side-channel habitat and reduced emigration flows. The dewatering risk associated with changes in operations is dependent on the physical attributes of the habitat and the magnitude of the change in flow. By December 1, an average of about 5 to 10 percent of juvenile CV spring-run Chinook salmon are expected to have passed the Red Bluff Diversion Dam rotary screw traps (University of Washington Columbia Basin Research 2019). With the remaining 90 to 95 percent of Sacramento River juvenile CV spring-run Chinook salmon upstream of the Red Bluff Diversion Dam as of December 1, a large proportion of the population would be expected to be exposed to the river conditions that result from the Winter Minimum Flows. The greatest impact posed by these operations would occur when December flows are reduced to 3,250 cfs. The impact associated with these operations is reflected in the proportion of years that Keswick flows in December would be no greater than 3,250 cfs.

Similar to the effects to SR winter-run Chinook salmon, juvenile CV spring-run Chinook salmon stranding generally results from reductions in flow that occur over short periods of time, and analytical planning tools cannot predict with certainty the level of effect of possible stranding on fish. The potential for juvenile stranding would also persist as operations continue to target lower reservoir releases in the fall and winter to maximize storage. NMFS expects that stranding of at least a small proportion of CV spring-run Chinook salmon juveniles will continue with proposed action implementation that will negatively affect exposed individuals.

Stranding is a potential source of mortality for juvenile CV spring-run Chinook salmon, particularly during periods of fluctuating water levels. This occurs when receding waters isolate juveniles in off-channel habitats like gravel bars and side channels. Although a natural process, stranding leaves fish vulnerable to predation, poor water quality and desiccation. Stranding can also induce sublethal effects, including metabolic stress and hypoxia, which can have long-term consequences for growth and survival. With regard to CV spring-run Chinook salmon redds, the USFWS (2006) flow fluctuation and redd dewatering relationship indicates that from August through October there is a risk of redd dewatering. This model provides a relative estimate of juvenile salmonid stranding potential in the Sacramento River. Focusing on the vulnerable fry

stage (first 3 months), the study identified 107 potential stranding sites between Keswick Dam and Battle Creek. The analysis combined field surveys, aerial photography, and hydraulic modeling to estimate the surface area of potential stranding habitats at different flows. Snorkel surveys provided fish density estimates, allowing for the conversion of stranded area to estimated numbers of stranded juveniles. The stranding flow is defined as the flow at which the connecting channel between the main river and the stranding site reaches a critical shallow depth (0.1 feet), essentially isolating the juveniles. Daily stranding potential was calculated over a 100-year period, considering seasonal variations (ACID dam boards in/out) and fry presence for different salmonid species. The analysis acknowledges potential overestimation due to daily independent calculations and the assumption of 100 percent mortality in stranded habitats. However, these biases are assumed to affect all management alternatives equally, so the model can be used for relative comparison value.

As a result of the proposed action, an increase of about 8 percent in redd dewatering is anticipated for CV spring-run Chinook salmon egg incubation in the Sacramento River from Keswick Dam to the Battle Creek confluence, across all water year types (Appendix L, Attachment L, Table X-13 in U.S. Bureau of Reclamation 2023-2024). These results are analyzed in a comparative manner because the redd dewatering analysis models each day independently, thereby overcounting dewatered redds. However, the bias applies equally to the alternatives and, therefore, can provide relative estimates of redd dewatering potential. In an absolute sense, under the proposed action, the rounded estimated percent of redd dewatering potentials for CV spring-run Chinook salmon egg incubation in the Sacramento River from Keswick Dam to the Battle Creek confluence average 18 percent across all years, and are 25 percent in wet years, 29 percent in above normal years, 13 percent in below normal as well as dry years and 8 percent in critical years. The severity of the stressor is lethal (eggs killed when a redd is dewatered), the proportion of the population exposed is medium (from 8 to 29 percent of redds dewatered), the frequency of exposure is high (occurring in all water year types), the magnitude of effect is high, and the weight of evidence is medium (since the statistical methods and spatial resolution of the model may be insufficient to capture the nuances of habitat variations (e.g., refugia) or the full extent of the utilized habitat area (e.g., upstream or downstream of the surveyed transects; Railsback 2016).

Yearling rearing and migration are also expected to experience impacts to stranding due to the proposed storage and release of water, although it will be variable across water year types. Based on modeling of potential juvenile stranding for CV spring-run Chinook salmon fry rearing in the Sacramento River from Keswick Dam to the Battle Creek confluence, the proposed action, on average, will result in 7,916 juveniles potentially stranded. Relative to the NAA, the proposed action on average will have similar amounts of stranding averaged across all water year types, although this is a result of decreased stranding in wet and above normal years but increased stranding in below normal, dry and critical years. Similarly, relative to EXP3, the proposed action is expected to reduce stranding by 6 to 17 percent in relatively wetter (wet and above normal) years. However, it is expected to increase stranding by 5 to 16 percent in drier (below normal, dry and critical) years (Table 19). The severity of the stressor is lethal (stranded fish may be killed by predators or desiccation), the proportion of the population exposed is medium, the frequency of exposure is medium, the magnitude of effect is high, and the weight of evidence is high.

Table 19. Potential juvenile stranding (number of individuals) for Central Valley spring-run Chinook salmon fry rearing in the Sacramento River from Keswick Dam to the Battle Creek confluence for the proposed action (Alt2v1), no action alternative (NAA), and EXP3.

Water Year Type	Proposed Action (Alt2v1)	NAA	EXP3
Wet	9,354	9,639	11,335
Above Normal	8,632	8,837	9,226
Below Normal	7,250	7,231	6,542
Dry	7,087	7,422	6,726
Critical	6703	7,384	5,787
All	7,916	8,213	8,199

Source of information: LTO Appendix L – Shasta Cold Water Pool Attachment L, Table X-6 in (U.S. Bureau of Reclamation 2023-2024)

With relation to the stressors of spawning habitat, NMFS considers that the managed changes in the hydrograph can reduce access to riparian habitat and instream cover both in the immediate area of releases and further downstream (e.g., less frequent inundation of side channels). These changes can reduce accessibility to habitat that may support successful out-migration survival by providing rearing areas, refuge, or increased food availability. Under the proposed action, the expected WUA for spring-run Chinook salmon spawning in the Sacramento River from Keswick Dam to the Battle Creek Confluence ranges from about 343,000 in wet years to about 448,000 in critical years, with an average of about 400,000 across all years modeled. There is minimal change (<1 percent averaged across all water years) in spawning habitat as measured by weighted usable area, relative to NAA, but a 12-percent decrease relative to EXP3 (Appendix O, Habitat Attachment XX, Table X-17 in U.S. Bureau of Reclamation 2023-2024). However, the magnitude of the effect is low, due to the small size of the spawning population of CV spring-run Chinook salmon spawn in the Sacramento River. Therefore, in summary, the severity of the stressor is sublethal (lack of spawning habitat reduces the number of suitable places for adults to lay their eggs, leading to fewer offspring, even without directly killing adult fish), the proportion of the population exposed is small (since they primarily spawn in smaller tributaries rather than the mainstem Sacramento River), the frequency of exposure is medium (with effects across all water years, but a low variability due to the proposed action), the magnitude of effect is low, and the weight of evidence is medium (informed by the relative impacts of the model runs).

7.1.1.2.2.4.2.4. Redd Quality

The downstream extent of usable spawning habitat is affected by available flows and temperatures from Keswick Reservoir. Adequate flows are essential for maintaining suitable water depths and velocities, providing access to spawning grounds, ensuring gravel recruitment and cleansing, and regulating intragravel flow and redd stability. The interplay of flow and

temperature impacts the spawning success of CV spring-run Chinook salmon reproduction. There is no explicit modeling of redd quality available so the discussion below uses flow as a surrogate since excessive fine sediment accumulation within the riverbed can significantly impair the incubation of CV spring-run Chinook salmon eggs and subsequent alevin development. Increased surface flows promote greater hyporheic exchange, which in turn increases dissolved oxygen delivery to incubating embryos.

Fall operations is the seasonal operations period that has the most consequential impact on redd quality, and it is influenced mainly by the annual temperature management plan developed for SR winter-run Chinook salmon. In the worst case in the recent decade, 2021, this increase in temperatures began in the second half of August, but in some years, the increase began in September or October. By November and December, temperatures have generally peaked and begin to descend (Figure 48). We also expect that any redds constructed downstream from the temperature management reaches for SR winter-run Chinook salmon management will be affected by suboptimal conditions because water temperatures are likely to exceed levels that support egg survival.

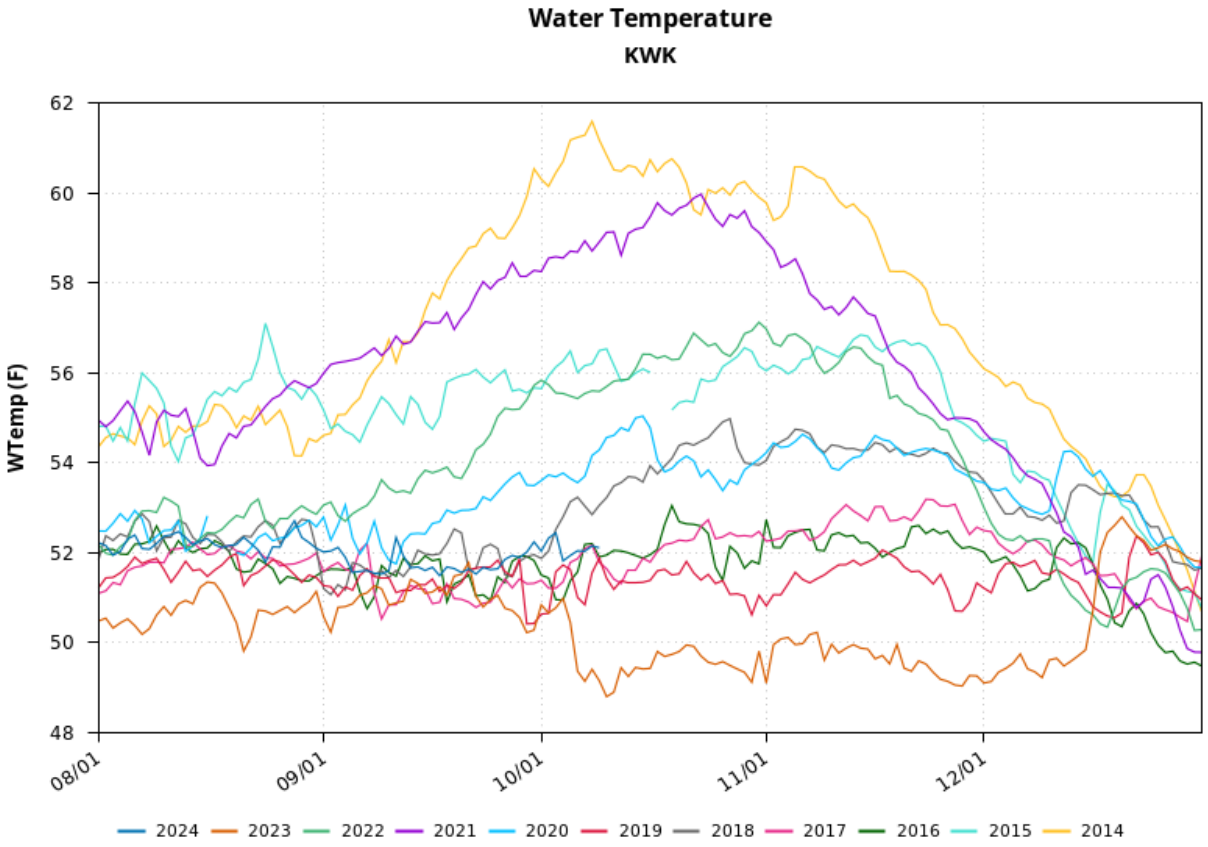


Figure 48. Water temperatures at Keswick gauge from August through December of 2014–2024.

Source: SacPAS (University of Washington Columbia Basin Research 2024b). Available from www.cbr.washington.edu/sacramento/data/query_river_allyears.html

Under the proposed action, the average monthly flow in the Sacramento River at Bend Bridge will be 7,606 cfs in November, 12,218 in December and 15,381 in January. This is largely

similar to the anticipated flows under the NAA, 7,366 cfs in November, 12,007 cfs in December and 15,143 cfs in January (Tables F.2.2-4-6b and F.2.2-4-10b in Appendix F: Modeling Section 1-1, CalSim 3, DSM2 and HEC5Q Modeling Simulations and Assumptions in U.S. Bureau of Reclamation 2023-2024). However, although the BA suggested an improvement for this stressor, modeling indicates that the long-term average flow for the Sacramento River at Bend Bridge will be lower under proposed action operations than EXP3 for winter months such as December (see Figure F.2.2-4-6 and Figure F.2.2-4-9 in Appendix F: Modeling Section 1-1, CalSim 3, DSM2 and HEC5Q Modeling Simulations and Assumptions in U.S. Bureau of Reclamation 2023-2024). Specifically, in December, flow at Bend Bridge under Alt2v1 will be 12,218 cfs, versus 19,524 under EXP3. As the BA summarizes, "Increased surface flows are likely to increase hyporheic flows that improve dissolved oxygen and additionally may reduce sedimentation improving egg and alevin essential functions and development (Bennett 2003). Build-up of fine sediment can decrease permeability, decrease interstitial flow, and reduce oxygen availability for embryos (Bjornn and Reiser 1991)" (U.S. Bureau of Reclamation 2023-2024). Therefore, proposed lower flows during the egg incubation to fry emergence period on the Sacramento River, approximately from September through February for CV spring-run Chinook salmon, are expected to exacerbate the redd quality stressor. The severity of the stressor is sub-lethal (increasing metabolic stress on incubating eggs), the proportion of the population exposed is small (the majority of spawning is not on the mainstem Sacramento River), the frequency of exposure is high (70 percentile exceedance probability of lower flows under the proposed action relative to EXP3, per Figure F.2.2-4-9), the magnitude of effect is medium, and the weight of evidence is medium (field data for this population is limited but hypoxia is a well-documented stress on salmon eggs).

7.1.1.2.2.4.2.5. Out-Migration Cues

The proposed storage of water may increase the out-migration cue stressor. During the juvenile rearing and out-migration period, from November through June, storage of water in Shasta Reservoir associated with the proposed action will reduce downstream flows on the Sacramento River, particularly in the winter and spring from December through April, and may affect juveniles' cue to migrate and their out-migration travel rates. Central Valley spring-run Chinook salmon rely on increased spring flows as a primary cue to initiate their downstream migration. Higher storage could lead to reduced spring flows and delayed peak flows which in turn could delay migration and reduce survival, including reducing rearing habitat and increased predation risk. The estimated months of highest occurrence for the CV spring-run Chinook salmon fry life stage are November through February (Appendix L, Attachment L, Table X-3 in U.S. Bureau of Reclamation 2023-2024), with out-migration extending through June, and other life history strategies, such as yearlings, also being observed in the CV spring-run Chinook salmon juvenile population (Cordoleani et al. 2021). Therefore, higher flows to aid out-migration are potentially important year-round, to support early, intermediate, and late out-migrants from the mainstem Sacramento River and its tributaries, such as Mill and Deer creeks.

Modeling indicates that the long-term average flow for the Sacramento River at Bend Bridge will be lower under proposed action operations than EXP3 for winter months such as December (see Appendix F, Figures F.2.2-4-6 and F.2.2-4-9 in U.S. Bureau of Reclamation 2023-2024). Specifically, in December, flow at Bend Bridge under Alt2v1 will be 12,218 cfs, versus 19,524 under EXP3. Therefore, lower flows during the juvenile rearing to out-migration on the Sacramento River are expected to increase the out-migration cues stressor. However, the passage

of juvenile CV spring-run Chinook salmon at Red Bluff Diversion Dam is highest from February through May, and peaks during March and April. April flows under the proposed action are higher than EXP3 for most years (from about the 30 to 80 percentile) and can be further augmented by the proposed Sacramento River Pulse Flows (Figure 49).

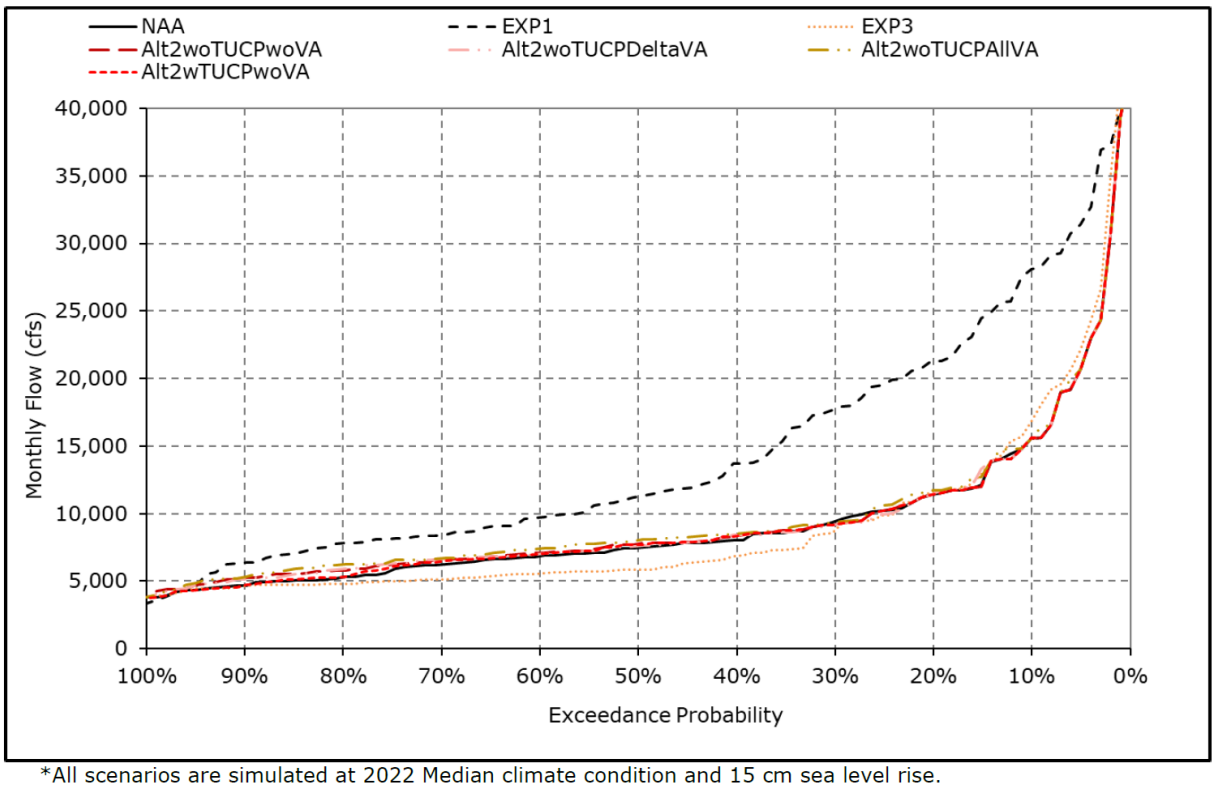


Figure 49. Sacramento River Flow below Red Bluff Diversion Dam in April.

Source: Appendix F: Modeling Section, Figure F.2.2-5-13 in (U.S. Bureau of Reclamation 2023-2024)

Considering these results, we expect that flows to cue out-migration during Fall and Winter operations will not be adequate in most years, since the flows are lower than the winter flows (e.g., December through February) that the species life history evolved under and is adapted for. However, the proportion of the population exposed to this stressor will be small, since the majority of the out-migration occurs later in the year. The severity of the stressor is sublethal, the proportion of the population exposed is large (since the Sacramento River is a central migratory corridor), the frequency of exposure is high (since the proposed action reduces December flows in most years), the magnitude of effect is medium, and the weight of evidence is medium.

7.1.1.2.2.4.2.6. Refuge Habitat and Food Availability and Quality

With relation to the stressors of Refuge Habitat and Food Availability and Quality, NMFS considers that the proposed managed changes in the hydrograph can reduce access to riparian habitat and instream cover in the immediate area of releases but perhaps more so further downstream (e.g., less frequent overtopping of Fremont Weir and access to Yolo Bypass habitat). However, we note that the proposed lower flows during this time of year would not likely result in changes to riparian habitat, morphology and function, or floodplain habitat in the

vicinity of Keswick releases. Decreased flows in the Sacramento River can reduce both suitable margin and off-channel habitats available as refuge habitat for juveniles.

The expected habitat for CV spring-run Chinook salmon rearing in the Sacramento River from Keswick Dam to the Battle Creek confluence, as measured by weighted usable area averaged across all water years, under both the proposed action and the NAA are about 248,000 for fry rearing and 200,000 for juvenile rearing. These are both higher relative to EXP3 by 7 percent for fry (266,000 versus 248,000) and 2 percent for juveniles (204,000 versus 200,000; Table X-19 and X-21, LTO Appendix O – Tributary Habitat Attachment XX, Sacramento River Weighted Usable Area Analysis in U.S. Bureau of Reclamation 2023-2024). There is also a decrease in the predicted mean rearing habitat quantities, in acres, for CV spring-run Chinook salmon in the Upper Sacramento River. When summed across all water years and months, modeling predicts a total loss of 62 acres of instream rearing (9-percent decrease) and 31 acres of floodplain rearing habitat (18-percent decrease; Tables 24 and 25 in LTO Appendix O – Tributary Habitat Attachment X, SIT LCM Habitat Estimates in U.S. Bureau of Reclamation 2023-2024). The decrease in Fremont Weir Spills and Yolo Bypass long-term average flows (Figures F.2.2-10-1 and F.2.2-11-1 in U.S. Bureau of Reclamation 2023-2024) will also reduce downstream habitat for juveniles. These impacts will affect juvenile rearing to out-migration, yearling rearing, and migration. The severity of the stressor is sublethal (reducing growth), the proportion of the population exposed is large (CV spring-run Chinook salmon have a broad period in which they potentially rear in the Sacramento River and its floodplains, which includes the Fall and Winter months), the frequency of exposure is low (the biggest relative impacts to WUA were mostly in wet and above normal years), the magnitude of the effect is medium, and the weight of evidence is high.

7.1.1.2.2.4.3. California Central Valley Steelhead Exposure and Response

7.1.1.2.2.4.3.1. Stranding Risk and Dewatering

California Central Valley steelhead express a diverse array of life-history strategies, including both anadromous and resident (i.e., rainbow trout) life histories. Anadromous and resident life histories can be adopted by individuals from the same sibling cohort, making determinations regarding run timing difficult. During the October to November timing of operations for the base flows for Shasta Refill and Redd Maintenance, including the Minimum Instream Flows proposed action component, the majority of adult CCV steelhead are migrating past Red Bluff Diversion Dam (McEwan 2001). The species response to fall flows of 3,250 cfs in the Upper Sacramento River would include stranding, increased competition and reduced spawning habitat availability related to less floodplain and side-channel habitat. The dewatering risk associated with changes in operations is dependent on the physical attributes of the habitat and the magnitude of the change in flow. Similar to the effects to SR winter-run Chinook salmon, juvenile stranding generally results from reductions in flow that occur over short periods of time, and analytical planning tools cannot predict with certainty the level of effect of possible stranding on fish. The potential for juvenile stranding would persist as operations continue to target lower reservoir releases in the fall and winter to maximize storage. NMFS expects that the stranding of at least a small proportion of CCV steelhead juveniles will continue with the proposed action implementation that will negatively affect exposed individuals. The severity of the stressor is lethal (since stranded juveniles can die from desiccation, high temperatures, low dissolved oxygen, or higher levels of predation in a habitat disconnected from the main channel after flow

reductions), the proportion of the population exposed is small (the majority of estimated passage around Red Bluff Diversion Dam occurs in the springtime), the frequency of exposure is high (Shasta and Keswick dams alter natural river flows in most months and years), the magnitude of effect is medium, and the weight of evidence is medium. Modeling anticipates variable impacts of the proposed action on juvenile CCV steelhead stranding in the Sacramento River from Keswick Dam to Battle Creek depending on the water year type (from 15-percent decreases in above normal and dry years, to 26-percent increases in critical years; see Appendix L, Attachment L, Table X-8 in U.S. Bureau of Reclamation 2023-2024).

The potential for stranding of juveniles is highest in February and March, relative to April and May (Appendix L, Attachment L, Figure X-9 in U.S. Bureau of Reclamation 2023-2024). In critical years, the number of individual juveniles potentially stranded for CCV steelhead fry rearing in the Sacramento River from Keswick Dam to the Battle Creek confluence is projected to be 4,434 under the proposed action, nearly identical to 4,437 under the NAA, but higher than 3,526 under EXP3. However, averaged across all water years, the estimate is 5,277 under the proposed action, similar to both 5,636 under NAA and 5,398 under EXP3 (

Table 20). The modeling generally predicts higher stranding in wetter water years (with a maximum average of 7,973 under the proposed action occurring during wet years), although with some exceptions (e.g., lowest under the proposed action is predicted to be 3,544 in dry years, less than the 4,434 projected in critical years).

Table 20. Potential juvenile stranding (number of individuals) for California Central Valley steelhead fry rearing in the Sacramento River from Keswick Dam to the Battle Creek confluence under the proposed action (Alt2v1), no action alternative (NAA), and EXP3.

Water Year Type	Proposed Action (Alt2v1)	NAA	EXP3
Wet	7,973	8,337	8,127
Above Normal	5,242	5,331	6,172
Below Normal	4,175	4,425	3,864
Dry	3,544	4,374	4,167
Critical	4,434	4,437	3,526
All	5,277	5,636	5,398

Source of information: Appendix L, Attachment L, Table X-8 in (U.S. Bureau of Reclamation 2023-2024)

These absolute values need to be interpreted with the following uncertainties in mind: the method likely overestimates stranding because it analyzes each day independently, potentially counting the same fish multiple times; only fry are considered, as they are most vulnerable to

stranding, while older juveniles are less vulnerable and often migrate out of the study area before they are large enough to avoid stranding; the analysis assumes all stranded fry die, which is unrealistic since fry can sometimes move to deeper water or survive in stranded pools until the water returns; and the analysis assumes the river channel has not changed significantly since the data were collected (1998–2001), which might not be true. As discussed in the proposed action, the stranding results provide relative rather than absolute estimates of the number of juveniles stranded, which can provide a relative degree of impacts between alternatives (Appendix L in U.S. Bureau of Reclamation 2023-2024), and is therefore helpful in assessing the relative magnitude of effects. The severity of the stressor is lethal (since stranded juveniles can die from desiccation, high temperatures, low dissolved oxygen, or higher levels of predation in habitat disconnected from the main channel after flow reductions), the proportion of the population exposed is medium (the upstream reach of the Sacramento River especially impacted by Shasta Dam operations serves as rearing habitat for a proportion of CCV steelhead yearlings and young of year), the frequency of exposure is high (with effects in all water years), the magnitude of effect is high, and the weight of evidence is high.

7.1.1.2.2.4.3.2. Refuge Habitat and Food Availability and Quality

With relation to the stressors Refuge Habitat and Food Availability and Quality, NMFS considers that the managed changes in the hydrograph associated with the proposed action for Fall and Winter Baseflow Management for Shasta Refill and Redd Maintenance can reduce access to riparian habitat and instream cover both in the immediate area of releases and further downstream (e.g., less frequent inundation of side channels). These changes can reduce accessibility to habitat that may support successful out-migration survival by providing rearing areas, refuge, or increased food availability.

In general, winter baseflow management reduces the magnitude and frequency of discharge events that activate refuge habitat, influence food availability and quality, and may affect the growth and survival of individuals.

Decreased flows in the Sacramento River thereby reduce suitable margin and off-channel habitats available as refuge habitat for juveniles. Modeling indicates a decrease in rearing habitat. Proposed action flows are expected to decrease WUA by 2 percent for CCV steelhead juvenile rearing in the Sacramento River from Keswick Dam to the Battle Creek confluence (from about 750,000 under EXP3 to 732,000 under the proposed action; Appendix O, Attachment XX, Table X-12 in U.S. Bureau of Reclamation 2023-2024). The severity of the stressor is sublethal (decreasing growth), the proportion of the population exposed is medium (the upstream reach of the Sacramento River especially impacted by Shasta Dam operations serves as rearing habitat for a proportion of CCV steelhead yearlings and young of year), the frequency of exposure is medium (with measurable effects in most water years), the magnitude of effect is medium, and the weight of evidence is medium (impacts on foraging and diet are well documented but the model's design makes it better at showing comparative results (e.g., how much foraging changes compared to a baseline) rather than precise measurements (e.g., exactly how many fewer food items are found). Despite a substantial amount of historic monitoring for stranding (see Appendix L, Table 15 in U.S. Bureau of Reclamation 2023-2024), the overall weight of evidence regarding its impact is limited by the modeling approach employed (Railsback 2016). Specifically, the model utilizes surrogate habitat suitability data (from late fall-run Chinook salmon) for CCV steelhead, introducing a degree of uncertainty. Additionally, the

statistical methods and spatial resolution of the model may be insufficient to capture the nuances of habitat variations (e.g., refugia) or the full extent of the utilized habitat area (e.g., upstream or downstream of the surveyed transects). While the BA acknowledges alternative modeling approaches with potentially greater precision (e.g., mesohabitat or individual-based models), results from these methods are not presented (Appendix L – Shasta Coldwater Pool Management, Section 5.3.1 Early Life-Stage Survival Models in U.S. Bureau of Reclamation 2023-2024).

7.1.1.2.2.4.3.3. Water Temperature

Warmer water temperatures may add stress on adults taxed from escapement and reduce spawning success. Under the proposed action, 3 percent of months are expected to be outside the 41°F to 55°F water temperature range for successful CCV steelhead spawning for all years combined, at the KWK gauge, December through May. However, downstream at Red Bluff Diversion Dam, 34 percent of months are expected to be outside of this range, averaged across all years. Critical years exacerbate these conditions, with about 4 percent of months outside the temperature range at Keswick Dam and 40 percent at Red Bluff Diversion Dam.

Looking at the relative difference, there is a modest variation between the proposed action and EXP3 in the percent of months from December through May outside the 41°F to 55°F water temperature range for successful CCV steelhead spawning, depending on the water year type. Specifically, across all water year types, there is a 2-percent decrease expected in the percent of months outside that temperature range at the KWK gauge, as well as at Red Bluff Diversion Dam, although there is a small increase at the former location during dry years (Tables 18 and 19 in U.S. Bureau of Reclamation 2023-2024). The severity of the stressor is sub-lethal (stressing returning adults), the proportion of the population exposed is small (since they primarily spawn in smaller tributaries rather than the mainstem Sacramento River), the frequency of exposure is high (especially downstream at Red Bluff Diversion Dam), the magnitude of effect is medium, and the weight of evidence is medium.

Mortality of incubating eggs can occur due to increased metabolic demand and reduced dissolved oxygen in warmer water. Under the proposed action, about 46 percent of months (at Keswick Dam) and 54 percent of months (at Red Bluff Diversion Dam) are anticipated to be outside the 45°F to 52°F optimal egg incubation water temperature range for CCV steelhead from December through June for all years combined. As a relative difference compared to EXP3, the proposed action is expected to result in a 4-percent reduction at Keswick Dam and a 2-percent reduction at Red Bluff Diversion Dam in the months outside the 45°F to 52°F optimal egg incubation water temperature range for CCV steelhead, for all years combined from December through June (Tables 42 and 43 in U.S. Bureau of Reclamation 2023-2024). Note that there appears to be an error in the "All" water years row of Table 42 from the BA (U.S. Bureau of Reclamation 2023-2024). Recalculating the weighted averages resulted in higher respective values for the proposed action (increasing from 35 to 46 percent) and EXP3 (increasing from 39 to 50 percent). However, the difference between the proposed action and EXP3 remains about the same (4 percent). The severity of the stressor is lethal, the proportion of the population exposed is small (since they primarily spawn in smaller tributaries rather than the mainstem Sacramento River), the frequency of exposure is high (occurring from 42 to 47 percent of months, depending on the water year), the magnitude of effect is medium, and the weight of evidence is high.

7.1.1.2.2.4.3.4. Out-Migration Cues

Juvenile CCV steelhead can occur throughout the year, with some peaks observed in the passage at Red Bluff Diversion Dam in the Spring (particularly April and May) and Fall (August).

Similar to the Refuge Habitat and Food Availability and Quality stressor, winter baseflow management reduces the magnitude and frequency of discharge events that activate refuge habitat, influence food availability and quality, and may affect the growth and survival of individuals.

Modeling indicates that the long-term average flow for the Sacramento River at Red Bluff Diversion Dam under proposed action operations will range from moderate flows earlier in the winter (6,715 cfs in October to 7,706 cfs in November) to much higher flows in the ensuing months (12,438 cfs in December, 14,616 in January and 19,729 in February; see Table F.2.2-5-1b in Appendix F: Modeling Section 1-1, CalSim 3, DSM2 and HEC5Q Modeling Simulations and Assumptions in U.S. Bureau of Reclamation 2023-2024). Focusing on December flows, the 12,428 cfs average under the proposed action is substantially less than the 19,744 cfs under EXP3. The proposed storage of water in the Fall and Winter may increase the out-migration cue stressor. During the juvenile rearing and out-migration period, storage of water in Shasta Reservoir associated with the proposed action will reduce downstream flows on the Sacramento River, particularly in the winter and spring from December through April, and may affect juveniles' cue to migrate and their out-migration travel rates. Therefore, lower flows during the Juvenile Rearing to Out-Migration on the Sacramento River are expected to increase the out-migration cues stressor an unspecified amount due to fall and winter operations. The severity of the stressor is sublethal (delayed out-migration), the proportion of the population exposed is large (the Sacramento River is the primary out-migration route for the majority of Central Valley steelhead), the frequency of exposure is medium (since the peak of passage is in the Spring), the magnitude of effect is medium, and the weight of evidence is medium (supported by flow monitoring and some fish monitoring data to quantify the exposure).

7.1.1.2.2.4.3.5. Pathogens and Disease

Lower water temperatures are associated with a reduction in the prevalence of pathogens and diseases, potentially improving the fitness and migration success of adult CCV steelhead. Salmonid pathogens and diseases can spread vertically (parent to offspring) or horizontally (between individuals), as described by (Baxa-Antonio et al. 1992). Seasonal water management practices that reduce river flow can concentrate pathogens, facilitating horizontal transmission, and rising water temperatures can increase the virulence of pathogens. Research by McCullough (1999) indicates that diseases affecting salmonids become highly virulent at temperatures exceeding 59.9°F (U.S. Bureau of Reclamation 2023-2024).

For adult CCV steelhead migration, the proposed action may result in an exceedance of the pathogen virulence threshold of 59.9°F from July through March near Keswick Dam in 13.5 percent of months in critical years (with highest temperatures in September and October of those years) but does not exceed the threshold in any monthly averages for other water year types at that location (Table 10 in U.S. Bureau of Reclamation 2023-2024). Further downstream near Red Bluff Diversion Dam, the threshold is exceeded in 35 percent of months for critical years (Table 12 in U.S. Bureau of Reclamation 2023-2024), and downstream from there it is exceeded in 44 percent of months at Hamilton City (Table 11 in U.S. Bureau of Reclamation 2023-2024).

Moving further downstream from Keswick Dam, the exceedances increase while the influence of Shasta water operations on temperatures decreases (Daniels and Danner 2020) so that averaged across all years the percentage of months above the threshold increases from 2 percent at Keswick Dam, to 8 percent at Red Bluff Diversion Dam to 35 percent at Hamilton City.

The proposed action impacts are similar (within about 1 percent when averaged across all years) to the NAA. When looking at the impacts compared to the EXP3, for adult CCV steelhead migration, temperature modeling showed a 9-percent increase (from 4.3 percent under EXP3 to 13.5 percent under the proposed action) during critical years in the months above the pathogen virulence water temperature threshold (Table 10 in U.S. Bureau of Reclamation 2023-2024). Note that there were no months above the threshold for the other water year types (from dry to wet), whether for EXP3 or any of the Alt2 scenarios. However, downstream at Hamilton City and Red Bluff Diversion Dam. For example, there is a 7-percent decrease (from 16 percent under EXP3 to about 9 percent under the proposed action) in the months above the threshold for all years combined at the Red Bluff Diversion Dam, December through May (Table 25 in U.S. Bureau of Reclamation 2023-2024). A broader range of impacts under the proposed action is evident further downstream at Red Bluff Diversion Dam in the December through May timeframe, although it does not correlate with hydrology as the most exceedances were in dry years (12.5 percent), followed by above normal (10.1 percent) then critical (9.5 percent) then wet (7.1 percent) and below normal (6.5 percent). For adults, the severity of the stressor is lethal (pathogens disrupt vital physiological functions, compromise immune responses, and can cause direct tissue damage, ultimately leading to mortality), the proportion of the population exposed is medium (the upstream reach of the Sacramento River especially impacted by Shasta Dam operations serves as adult migration habitat for a proportion of California Central Valley steelhead), the frequency of exposure is high (only in critical years at Keswick, but all water year types downstream), the magnitude of effect is high, and the weight of evidence is medium (supported by temperature and some fish monitoring data to quantify the exposure).

The relationship for juveniles follows a similar pattern where the percent of months above the 59.9°F pathogen virulence water temperature threshold for juvenile CCV steelhead rearing and out-migration by water year type is expected to increase by 1 percent in the Sacramento River at Keswick Dam, but decrease by 12 percent at the Red Bluff Diversion Dam (Tables 59 and 60 in U.S. Bureau of Reclamation 2023-2024). Under the proposed action, averaged across all years, 1.6 percent of months at Keswick and 13.5 percent of months at Red Bluff Diversion Dam were above the 59.9°F pathogen virulence water temperature threshold for juvenile CCV steelhead rearing and out-migration. The severity of the stressor is sub-lethal in the summer/fall and in the spring, and the proportion of the population exposed is medium in the summer/fall, but small in the spring. The frequency of exposure and weight of evidence for both are medium. As a result, the overall magnitude of the effect is medium for summer/fall and spring. Discussion of the later impacts are considered under Shasta Spring Operations. Additionally, under the proposed action, 17 percent of months, averaged across all years, will be above the 59.9°F pathogen virulence water temperature threshold for kelt emigration in the Sacramento River at the Red Bluff Diversion Dam, February through June. This is slightly better than NAA under which 26 percent of months will exceed the threshold, and EXP3 under which 34 percent of the months will exceed the threshold (Table 36 in U.S. Bureau of Reclamation 2023-2024). The BA (U.S. Bureau of Reclamation 2023-2024) notes that "Presence of pathogens and disease may increase stress on steelhead kelts, reducing fitness and impairing emigration. It is uncertain how

pathogens and disease may influence rates of anadromy and out-migration cues." For juveniles as well as kelts, the severity of the stressor is lethal (pathogens disrupt vital physiological functions, compromise immune responses, and can cause direct tissue damage, ultimately leading to mortality), the proportion of the population exposed is medium (the upstream reach of the Sacramento River especially impacted by Shasta Dam operations serves as juvenile and kelt migration habitat for a proportion of California Central Valley steelhead), the frequency of exposure is high (impacting all water year types), the magnitude of effect is high, and the weight of evidence is medium (supported by temperature and some fish monitoring data to quantify the exposure). Lastly, for the egg incubation life stage, about 13 percent of months averaged across all years (and up to 15 percent during critical years) will be above the 59.9°F pathogen virulence water temperature threshold for CCV steelhead egg incubation and fry emergence by water year type in the Sacramento River at the Red Bluff Diversion Dam from December through June. This represents an anticipated 12-percent decrease in the proposed action relative to EXP3 (Table 49 in U.S. Bureau of Reclamation 2023-2024). For the egg incubation life stage, the severity of the stressor is lethal (elevated water temperatures can increase the susceptibility of CCV steelhead eggs to pathogens, reduce dissolved oxygen levels critical for development, and disrupt embryonic development, leading to mortality), the proportion of the population exposed is small, the frequency of exposure is medium, the magnitude of effect is low, and the weight of evidence is medium.

7.1.1.2.2.4.3.6. Spawning Habitat

Dams block the natural flow of coarse sediments (e.g., gravel and cobble) that CCV steelhead need for constructing redds. The lack of sediment transport can lead to the riverbed becoming compacted and armored, making it unsuitable for redd construction. Additionally, dams can alter the flow regime of the river, reducing the frequency and intensity of high flows that would naturally scour the riverbed and create new spawning habitat. The lack of suitable spawning habitat may reduce spawning success. If there is not enough suitable habitat, female CCV steelhead may not be able to build redds or may be forced to build them in suboptimal locations, leading to lower egg survival rates. In reaches with extreme habitat limitation, CCV steelhead may build redds on top of existing ones, a phenomenon known as superimposition. Finally, if females cannot find suitable spawning sites, they may reabsorb their eggs or not fully release them, leading to reduced reproductive success. The modeling in the BA represents spawning habitat in terms of WUA, which is calculated based on substrate particle size, water depth, and flow velocity.

The proposed action supports approximately 10 to 13 acres of adult spawning habitat downstream from Keswick Dam, with a WUA of 99,753 (Table 4 in Attachment X of Appendix O and Table X-6 in Attachment XX of Appendix O in U.S. Bureau of Reclamation 2023-2024). The modeling indicates that WUA will be highest in critical years and lowest in wet years, and predicts greater spawning habitat quantities in the spring (e.g., April) relative to winter (e.g., January). The spawning habitat stressor can result in mortality when habitat is limited, leading to incomplete egg expression or redd superimposition. These density-dependent effects are less likely to occur in the Sacramento River due to the relatively small population size of CCV steelhead. Modeling indicates that the proposed action will have negligible changes relative to both the NAA and EXP3 resulting in changes of less than an acre in adult CCV steelhead spawning habitat for each month modeled from January through April relative to those other two alternatives. Likewise, modeling indicates less than a 2-percent change in WUA for CCV

steelhead spawning relative to the NAA and EXP3 alternatives (from 99,753 under the proposed action to 99,729 under NAA, to 97,954 under EXP3; Appendix O, Attachment XX, Table X-6 in U.S. Bureau of Reclamation 2023-2024).

The effect of the stressor of reduced spawning habitat is potentially sublethal, with suboptimal redd locations leading to reduced survival rates, but in this case is considered lethal when redd superimposition or failure to locate suitable spawning habitat causes egg mortality. The proportion of the population exposed to this stressor is small (the majority of CCV steelhead spawning is on tributaries), the frequency of exposure is low (due to low population numbers, redd superimposition is likely to be less frequent), and the magnitude of the effect is low. The weight of evidence supporting these conclusions is moderate.

7.1.1.2.2.4.3.7. Food Availability and Quality

The flows in the Sacramento River at Bend Bridge under the proposed action will impact food availability and quality, with modeling anticipating that monthly average flows will be 6,814 cfs (October), 7,606 cfs (November), 12,218 cfs (December), 15,381 cfs (January), 19,452 cfs (February), 13,997 cfs (March), 9,801 cfs (April), 9,485 cfs (May), 10,537 cfs (June), 13,261 cfs (July), 9,987 cfs (August) and 7,453 cfs (September). Decreased quality and quantity of food due to flow alterations for foraging juvenile CCV steelhead will impact growth rates. Modeling indicates that the long-term average flow for the Sacramento River at Bend Bridge will be lower under proposed action operations than EXP3 for winter months such as December during the juvenile life stage (see Appendix F, Figure F.2.2-4-6 and Figure F.2.2-4-9 in U.S. Bureau of Reclamation 2023-2024). The severity of the stressor is sublethal (reducing growth rates, delaying smoltification, and increasing vulnerability to disease and predation, ultimately hindering their survival and reproductive success), the proportion of the population exposed is medium (the upstream reach of the Sacramento River especially impacted by Shasta Dam operations serves as juvenile habitat for a proportion of California Central Valley steelhead), the frequency of exposure is high (impacting most water years), the magnitude of effect is medium, and the weight of evidence is medium (since the impacts on foraging and diet are well documented but a surrogate is used for this line of evidence).

7.1.1.2.2.4.4. Southern Distinct Population Segment of Green Sturgeon Exposure and Response

7.1.1.2.2.4.4.1. Stranding Risk and Seasonal Migration Cues

Because sDPS green sturgeon life history timing is such that spawning occurs from April through July, with the median spawning in May (Poytress et al. 2015), it is unlikely that sDPS green sturgeon will be present in the Upper Sacramento River in the December-February period when Reclamation is managing the Baseflows for Shasta. Southern DPS green sturgeon life history timing is such that it is unlikely that sDPS green sturgeon will be present in the Upper Sacramento River when Reclamation is managing flows to Baseflows for Shasta Refill and Redd Maintenance, including Minimum Instream Flows. The farthest upstream spawning event documented occurred near Inks Creek at river mile 264 (between the BND and JLF gauges, and about 38 river miles downstream of Keswick Dam). Adult sDPS green sturgeon migrate upriver from March to early April, and spawn from April through July, with the median spawning in May (Poytress et al. 2015), often coinciding with high Delta outflow in the spring. Therefore, reductions in late winter flows that affect Delta outflow in February and March are likely to

impact spawning migration cues. While changes in low flows are unlikely to influence the frequency, magnitude, or duration of the higher flows to which sturgeon respond, we consider that the managed changes in the hydrograph can reduce the strength of the seasonal spawning migration cues.

7.1.1.2.3. Shasta Spring Operations

Minimum winter reservoir releases are maintained into the spring until flows are needed to support Sacramento River instream demands and Delta outflow requirements, or releases are required for flood control operations. The CVP releases for Delta outflow requirements are coordinated to draw from both Shasta and Folsom reservoirs. Both reservoirs have substantial temperature control requirements, and both need to build substantial storage to be able to fully meet their respective summer temperature compliance requirements. The proposed action indicates that Reclamation operations intend to balance each reservoir's demands so that the filling of one limits the impact to the other. An overarching objective for Reclamation when operating the CVP is to attain maximum reservoir storage by the end of the flood control season (i.e., the end of May) while still meeting all other authorized project purposes.

Under unimpaired conditions, the median monthly flows from February through April would naturally have been nearly double the flow rate currently managed to flow into the Upper Sacramento River in more recent decades (Zimmerman et al. 2023). In the Sacramento River, the dynamic natural flows that would result from unregulated tributary contributions have been replaced by a spring base flow—a single minimum instream flow intended to be sufficient to maintain aquatic species during crucial low-flow periods. This is in contrast to the tributaries of the Upper Sacramento River, which mostly have unmodified hydrographs subject to a seasonal flow regime. This contrast between the unmodified flows of the tributaries and the minimum flows in the main stem creates a hydrologic disconnect for juveniles migrating out of the tributaries. Juvenile CV spring-run Chinook salmon migration out of Mill and Deer creeks begins in late March, extends through May, and is triggered by spring storm events or warming air temperatures causing rapid snowmelt. Peak migration out of these tributaries typically occurs early to mid-May, according to 15 years of rotary screw trap data (1995–2010, California Department of Fish and Wildlife 2024b). For those fish originating from Battle, Cottonwood, and Clear creeks, as well as from the mainstem Sacramento River, juvenile migration past Red Bluff Diversion Dam occurs from November to May (University of Washington Columbia Basin Research 2024a). These fish are, therefore, subject to the drastically reduced managed spring flow hydrograph and the resulting low-flow habitat conditions created by the spring base flows. The managed changes in the hydrograph can reduce the strength of the seasonal spawning cues for this species, and a managed spring pulse flow could alleviate the effects of the managed low flows.

Salmon and sturgeon have access to floodplain habitats, such as the Yolo and Sutter bypasses in springtime during higher flow events, and the quantity of floodplain available for rearing during drought years is currently limited. The Yolo Bypass Salmonid Habitat Restoration and Fish Passage Implementation Plan, including notching the Fremont Weir, is a concurrent action, separate from this consultation, which will provide access to floodplain habitat for juvenile salmonids over a longer period.

The spring flows proposed in the proposed action can exacerbate the Loss of Floodplain Habitat stressor. The flow reductions in March through May, which artificially detain high natural flows,

can be expected to limit access to food-rich floodplain habitat and reduce juvenile salmonid survival during rearing and downstream migration. An assessment of mark-recapture survival models in the Sacramento River main stem shows that flow correlates with out-migration success (Iglesias et al. 2017), providing additional evidence that flow is one of the most important factors affecting overall survival of Chinook salmon in the Central Valley (Kjelson and Brandes 1989, Zeug et al. 2014, Michel et al. 2015). Analysis of recent tagging data for both CV spring-run Chinook salmon and fall-run Chinook salmon show faster migration times and higher survival correlated with higher flow conditions (Cordoleani et al. 2018). Therefore, while reducing reservoir releases helps build storage for the following temperature management season, doing so also has a negative effect on floodplain access and, therefore, on downstream migration and survival.

7.1.1.2.3.1. Sacramento River Pulse Flows

To increase the out-migration survival of Chinook salmon, Reclamation would release up to 150 TAF in pulse flow(s) each water year, typically in the spring to benefit Chinook salmon in the Sacramento River watershed, when the pulse "does not interfere with the ability to meet temperature objectives or other anticipated operations of the reservoir" (U.S. Bureau of Reclamation 2023-2024). Pulse flows were initially intended to improve CV spring-run Chinook salmon survival, but the SHOT could determine to use pulse flows to improve SR winter-run Chinook salmon survival.

Reclamation's intent to implement this action, "...when the pulse does not interfere with the ability to meet temperature objectives or other anticipated operations of the reservoir" (U.S. Bureau of Reclamation 2023-2024) requires additional interpretation. In the broadest sense, any reservoir releases could, at some point in the future, interfere with reservoir operations since future inflows, temperatures, and systemwide demands are uncertain. Reclamation's CalSim modeling of the proposed action included the pulse flow only when it did not impact Shasta Reservoir's ability to fill to at least 4.1 MAF by the end of April (Appendix F in U.S. Bureau of Reclamation 2023-2024). However, since it is not a requirement statement in the proposed action, NMFS assumes that the pulse can be implemented, so long as the impacts on different species and runs are optimized and the water cost is less than 150 TAF, or a decision is made through the SHOT process to use the block of water for other salmon conservation purposes or priorities. For example, pulses may be timed to coincide with the historical CV spring-run Chinook salmon out-migration on Deer Creek, or on Mill Creek, or with the pulse flows on Clear Creek. In a year with low TDM forecasted for SR winter-run Chinook salmon, benefitting the CV spring-run Chinook salmon out-migration could be the optimal management choice. In critical years, the opposite may be optimal, forgoing one, or all, of the pulses to prioritize Shasta Reservoir storage and reduce TDM. This interpretation is supported by the description of the process in Reclamation's proposal, "The timing, magnitude, duration, and frequency of the pulse flows will be refined through the SRG to maximize multi-species benefits, which may include coordinating timing with natural flow events, potential storage management operations, potential SRSC demands and infrastructure limitations, and/or pulse flows in tributaries or reducing the volume of the pulse flow. The pulse flow volume and schedule will be developed through the SRG and elevated to the SHOT. Reclamation, through the SHOT, will discuss the plan and make any appropriate and/or necessary refinements prior to implementation" (U.S. Bureau of Reclamation 2023-2024). The discrepancy between the CalSim modeling, which does not account for the potential implementation of pulse flows under 4.1 MAF, and the proposed action,

which does not exclude this possibility, introduces uncertainty in the projected reservoir storage volumes. In some years, the model may overestimate the water available for other purposes by up to 150 TAF due to the potential implementation of pulse flows under the proposed action.

7.1.1.2.3.2. Adult Migration and Holding Temperature Objectives

Increased spring temperatures can impact SR winter-run Chinook salmon adults in multiple ways (gamete viability, spawning initiation, temperature shock, adult migration, disease risk, interaction with thiamine deficiency), as well as late fall-run Chinook salmon (impacts to redds). As is noted in EPA (2003), temperatures can influence the reproductive success of fish well before spawning by interfering with ovulation, spermatogenesis, decreased egg and sperm fitness and reduced embryonic survival rates. As Sauter (2001) summarizes, "There is some plasticity in timing of life stage events relative to annual climatic patterns (i.e., if sufficient energy remains in the adult body in the pre-spawning stage, some delay in spawning is feasible), and adjustments can be made throughout the life cycle, but inability to compensate fully tends to be expressed as population mortality, poor growth, reduced fecundity, and reduced fitness."

It is possible that high air temperatures and/or an intentional spring warm-water power bypass (e.g., in March or April, but particularly in May) could cause temperatures in the 56°F to 62°F range, rather than the typical 50°F to 55°F range, and may require additional protective measures. For example, the 2021 warm water bypass resulted in daily average water temperatures in May at the CCR gauge that were 2°F to 6°F above the 10-year average (Figure 50). Water temperatures at the CCR gauge are rarely greater than 58°F at any time of the year, and when they do occasionally occur (e.g., 2009, 2014–2015, and 2021–2022) it is in the summer or fall, rather than in the spring, as occurred in 2021 (Figure 51).

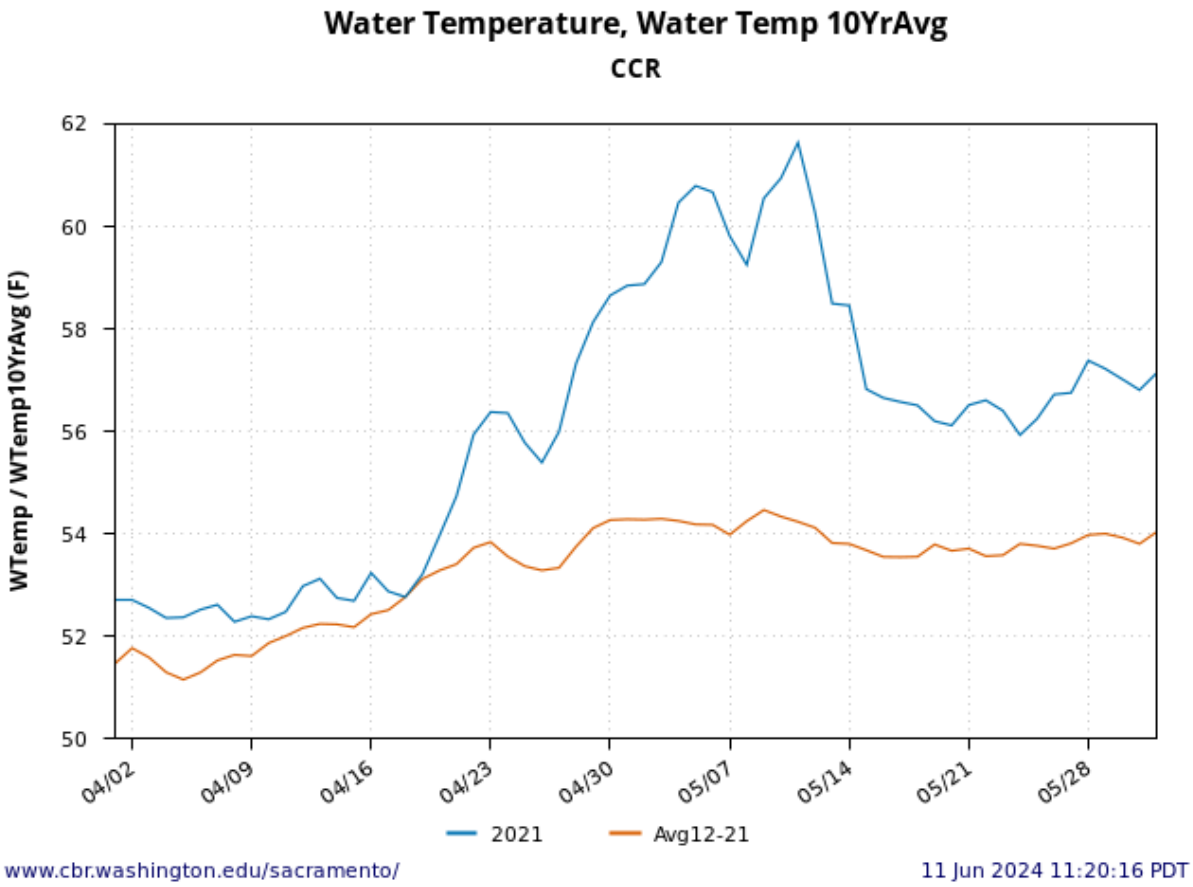


Figure 50. Water temperature in the Sacramento River above Clear Creek (CCR) in April and May 2021, versus the 10-year average.

Source: SacPAS (University of Washington Columbia Basin Research 2024b). Available from www.cbr.washington.edu/sacramento/data/query_river_allyears.html

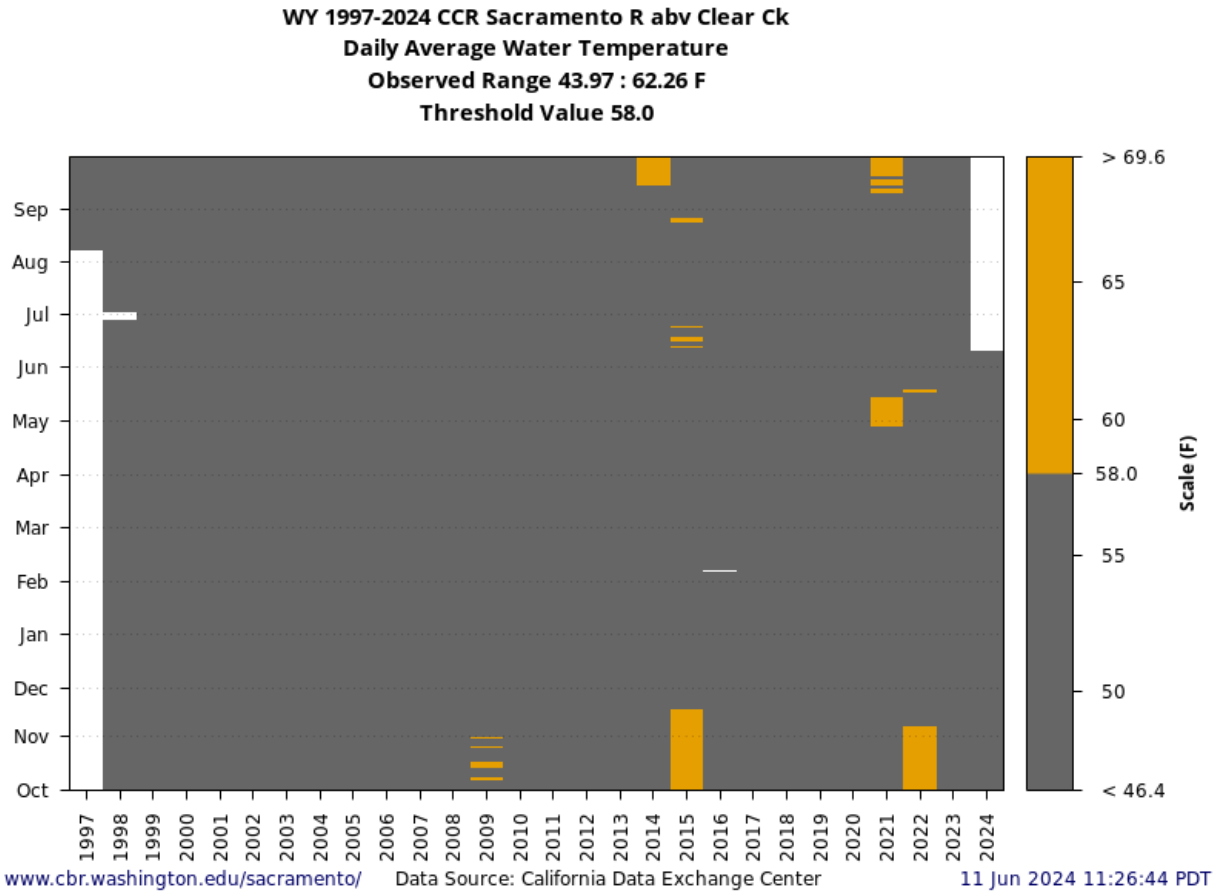


Figure 51. Water temperature in the Sacramento River above Clear Creek (CCR) from 1997 to 2024 compared to a threshold value of 58 degrees Fahrenheit. Water temperatures at the CCR gauge are rarely greater than 58°F (orange) at any time of the year, and when they do occasionally occur (e.g., 2009, 2014–2015, and 2021–2022) it is in the summer or fall, rather than in the spring, as occurred in 2021.

Source: SacPAS (University of Washington Columbia Basin Research 2024b). Available from www.cbr.washington.edu/sacramento/data/query_river_graph.html

Under circumstances where these conditions may cause water temperatures to rise to concerning levels prior to the completion of the final temperature management plan (TMP), Reclamation will begin temperature management as early as March 1st to target water temperatures of 58.0°F daily average at the Sacramento River at the CCR gauge. Reclamation, through the SRG and SHOT, may propose a different temperature based on the potential impacts to SR winter-run Chinook salmon spawning and egg incubation in the developing TMP.

7.1.1.2.3.3. Exposure and Response to Shasta Spring Operations

7.1.1.2.3.3.1. Sacramento River Winter-Run Chinook Salmon Exposure and Response to Individuals

7.1.1.2.3.3.1.1. Refuge Habitat and Food Availability and Quality

Under the proposed action, the expected weighted usable area for SR winter-run Chinook salmon fry rearing in the Sacramento River from Keswick Dam to the Battle Creek confluence averaged across all water years is about 266,000. It is not possible to definitively answer whether this volume of WUA is adequate for supporting habitat and food availability and quality for the species given the limitations of the model approach (rearing depends on factors beyond the habitat modeled, particularly water temperature, predation pressure and competition), WUA is a relative measure of habitat suitability (i.e., it does not tell us how many fry the habitat can support). We do not have a WUA benchmark value known to support healthy populations in the past, nor a WUA target established in recovery plans, nor data showing how fry survival and growth conform to these WUA expectations. The line of evidence, therefore, is most useful in a comparative sense to understand the incremental effects relative to historic and non-discretionary operations. There are minimal differences (less than 1 percent change) between the proposed action and NAA, but there are predicted 1 to 12-percent decreases (depending on water year type) in rearing habitat for SR winter-run Chinook salmon juvenile rearing in this reach when comparing the proposed action to EXP3 (Appendix O, Attachment XX, Table X-7 in U.S. Bureau of Reclamation 2023-2024). For refuge habitat and food availability and quality, the severity of the stressor is sublethal (lack of refuge habitat and poor food availability and quality can sublethally harm SR winter-run Chinook salmon in the Sacramento River by increasing stress, reducing growth and fitness, and making them more susceptible to disease and predation), the proportion of the population exposed is large (the single population is located downstream of Keswick Dam and directly influenced by its operations), the frequency of exposure is medium (with minimal relative impacts in below normal, dry, and critical years, but larger differences in above normal and wet years), the magnitude of effect is medium, and the weight of evidence is medium (since the impacts on foraging and diet are well documented but a surrogate is used for this line of evidence).

7.1.1.2.3.3.1.2. Water Temperature, Pathogens, and Disease

Excessive temperatures can stress adult holding and spawning by decreasing gamete viability, shifting the initiation of spawning, slowing or blocking migration, increasing disease, and potentially interacting with other physiological stressors, such as thiamine deficiency. During the springtime, decreased temperature stress from cooler river release could alleviate temperature stress for holding SR winter-run Chinook salmon adults, which is further supported by Reclamation's proposal of adult migration and holding temperature objectives. Note that increased temperatures from a warm water power bypass during this period to improve summer and fall conditions could negatively impact spring time water temperatures to the detriment of adults. This action is not included in the modeling (Appendix F: Modeling Section 1-1 in U.S. Bureau of Reclamation 2023-2024) but is analyzed under the drought toolkit along with other adaptive management tools. The proposed action is expected to maintain water temperatures that are below the threshold of 59.9°F for increasing pathogen virulence for most months and Reclamation will begin temperature management as early as March 1 to target water temperatures of 58.0°F daily average at the CCR gauge. Adult SR winter-run Chinook salmon

typically experience low levels of pre-spawning mortality. From 2006 to 2024, pre-spawning mortality of females has ranged from 0 to 5.5 percent, with the typical range being 0 to approximately 3 percent. In 2021, the temperature threshold was exceeded during a deliberate warm water bypass release that was intended to help store cold water behind Shasta Dam for use during summer water temperature management. This action may have resulted in the increase in adult pre-spawn mortality of 5.5 percent; however, pathology investigations at the USFWS CA-NV Fish Health Center captured and evaluated three live adult females between June 10 and 16 of that year and found, "no single infectious agent or tissue abnormality common to all 3 adult females. Bacteria and most of the parasites observed are common to this population and deemed of low severity (i.e., unlikely to invoke disease state)" (Foott 2024). Based on the temperature modeling results, monthly temperature averages at the CCR gauge during critical years will average 52°F in March and 55°F in April (Table F.2.11-6-1b in Appendix F of U.S. Bureau of Reclamation 2023-2024) and the proposed action explicitly aims to protect adult migration and holding below 58°F during these months. Therefore, we do not expect that increased temperatures caused by the proposed action would increase the occurrence of pre-spawn mortality, which is influenced by several factors, including those originating in other reaches of the river.

The effect can also be quantified by the percent of months outside the optimal 42.1°F to 55°F water temperature range for successful holding of SR winter-run Chinook salmon, January through July (Table 8 in U.S. Bureau of Reclamation 2023-2024). These results report that the proposed action (Alt2v1 model run) will result in 9.7 percent of months outside the temperature range, an improvement on the EXP3 run of 15.7 percent, and even more so relative to NAA, which exceeded this target in 19.3 percent of months. This indicates that the proposed action will result in a large proportion of months (more than 90 percent) suitable for spawning and holding. This effect will support spawning success and minimize temperature pre-spawn mortality for SR winter-run Chinook salmon.

Spring time water temperatures can also secondarily impact pathogens and disease on adults. The percent of months above the 59.9°F pathogen virulence water temperature threshold for adult SR winter-run Chinook salmon holding and spawning in the Sacramento River at the CCR gauge from January through July was 0 percent for both the proposed action and EXP3 (Table 10 in U.S. Bureau of Reclamation 2023-2024). However, daily temperatures in excess of 60°F were experienced in recent droughts (e.g., 2021) during adult holding and spawning, indicating the potential for impacts under existing conditions. The severity of the stressor is lethal (causing or contributing to pre-spawn mortality), the proportion of the population exposed is large (the single population is located downstream of Keswick Dam and directly influenced by its operations), the frequency of exposure is low (in critical years, potentially during warm water power bypasses), the magnitude of effect is medium, and the weight of evidence is medium (based on the recent documentation of disease and pre-spawn mortality in adults).

7.1.1.2.3.3.1.3. Migration Cues

The proposed pulse flow would occur in the spring when the majority of SR winter-run Chinook salmon juveniles either have entered the Delta or have completed their migration to the ocean (around March 1 to May 15). Rotary screw trap data over the last 10 years from Knights Landing, located just upstream of the Delta, show that by early to mid-February, 95 percent of SR winter-run Chinook salmon juveniles have entered the Delta (Figure 52) and migrated

downstream past the influence of a spring pulse flow. The proportion of SR winter-run Chinook salmon juveniles exposed to the spring pulse is expected to be small, occurring in fewer than 75 percent of years, and in those years, less than 5 percent of the year class is expected to be influenced. We expect increased survival for those juveniles exposed to the spring pulse as a result of decreased travel time and decreased predation risk.

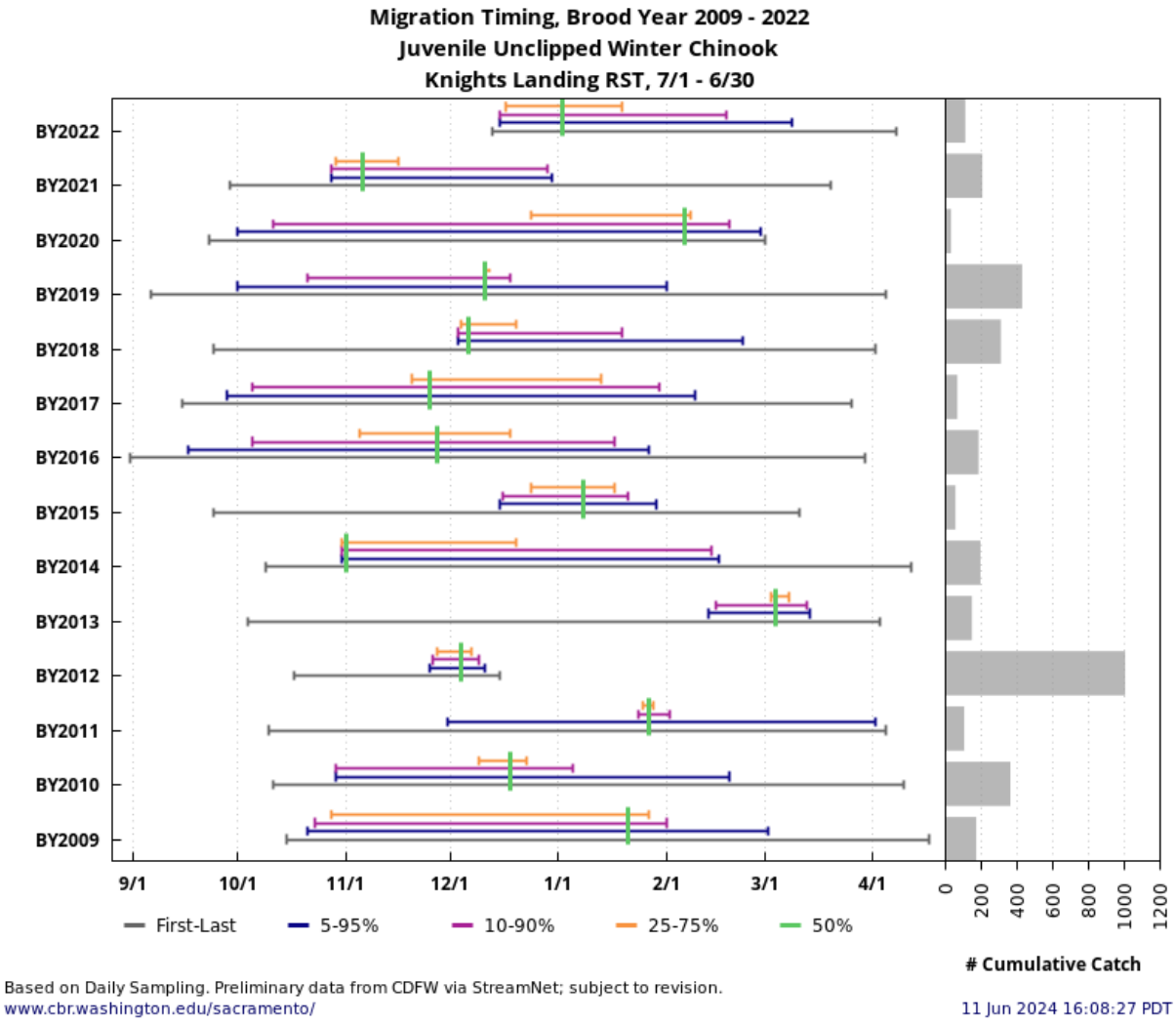


Figure 52. Knights Landing rotary screw trap (RST) juvenile Sacramento River winter-run Chinook salmon passage data from 2009 to 2022.

Source: SacPAS (University of Washington Columbia Basin Research 2024b). Available from www.cbr.washington.edu/sacramento/data/query_hrt.html

In addition to out-migration, spring pulses are also expected to benefit adult SR winter-run Chinook salmon migrating up the Sacramento River later in the spring. The spring pulses would provide improved flow conditions that, in turn, provide cooler temperatures (improved water temperature), and allow for better passage conditions as they move upstream from January through June. Specifically, pulse flows are designed to mimic the natural increase in river flow

that would occur during the spring snowmelt. This sudden increase in flow can act as an olfactory and behavioral cue for adult salmon migrating upstream. The increased water volume can also improve passage by clearing debris and sandbars, making the river channel deeper and easier to traverse. Tagging of Canadian summer-run Chinook salmon showed that pulses increased migration rates (although not predictably) and did not cause negative impacts, such as hyperactivity or downstream displacement (Hasler et al. 2014). Additional studies of the Sacramento River would be required to better predict the effects on adult SR winter-run Chinook salmon migration rates.

However, a springtime pulse could have an effect on the ability to manage cold water throughout the summer temperature management season. This could increase the amount of TDM SR winter-run Chinook salmon eggs are exposed to later in the year (e.g., September and October) when the cold water pool is smaller and, therefore, more constrained in its use for river temperature management. As previously mentioned, NMFS understands pulses may be implemented, so long as the tradeoffs are acceptable, and refined through the SRG to maximize multi-species benefits, as well as consider other factors (storage management operations, SRSC demands, infrastructure limitations, etc.).

7.1.1.2.3.3.1.4. Spawning Habitat

Spring Operations focus on building Shasta storage water supply and summer water temperature management for SR winter-run Chinook salmon.

Operations during this period affect early SR winter-run Chinook salmon adult spawners (e.g., beginning in April). The expected WUA for SR winter-run Chinook salmon spawning in the Sacramento River from Keswick Dam to the Battle Creek confluence is 551,576 under the proposed action, 545,832 under the NAA, and 592,655 under EXP3 (Table X-5 in U.S. Bureau of Reclamation 2023-2024). While WUA provides a relative measure of suitable habitat, without benchmarks, historical context, or population data, it is impossible to conclude whether the current WUA adequately supports SR winter-run Chinook salmon fry rearing due to the complex interplay of factors like water temperature, predation, and competition. Based on the current low abundance of natural spawners, density-dependent effects (e.g., redd superimposition) are less likely. However, SR winter-run Chinook salmon have been reduced to a single remaining natural population, and the space suitable for that population to spawn is shrinking over time due to a decline in areas with adequate water temperatures (e.g., 5 river miles to the SAC gauge in drought years, or 10 river miles to the CCR gauge in most other years). Therefore, the severity of the stressor is sublethal, the proportion of the population exposed is large (since the single population of SR winter-run Chinook salmon spawn in the Sacramento River watershed), the frequency of exposure is medium (particularly in years when escapement is high but the cold water pool is low), the magnitude of effect is medium, and the weight of evidence is medium (informed by recent spawning limitations and the aforementioned modeling).

7.1.1.2.3.3.1.5. Redd Quality

Increased flows improve dissolved oxygen and reduce sedimentation in redds, improving egg and alevin development. These effects are not directly modeled in the BA, but increased Shasta reservoir storage under the framework will allow increased river flows during egg incubation to fry emergence, thereby improving redd quality. Conversely, inadequate flows can compromise redd quality, leading to sedimentation that reduces oxygen availability and reduces incubating

egg survival by limiting their ability to meet temperature-dependent oxygen demands. The severity of the stressor is lethal, the proportion of the population exposed is large (since the single population of SR winter-run Chinook salmon spawn in the Sacramento River watershed), the frequency of exposure is high (since Keswick Dam discharges are the primary controlling factor in most years, although less so during the wettest periods with flood releases and substantial tributary inflow), the magnitude of effect is high, and the weight of evidence is medium (since SR winter-run Chinook salmon redds on the Sacramento River are closely monitored, although measures of dissolved oxygen in the egg pocket are difficult to directly observe).

Spring Operations focus on building Shasta storage water supply and summer water temperature management for SR winter-run Chinook salmon, which directly affects redd quality in the summer and fall. The EOA storage conditions have a direct influence on the biological objectives that influence redd quality. When February, March and April forecasts project that EOA storage will be greater or equal to 3.7 MAF, daily average water temperatures of 53.5 will be managed at or below the CCR gauge from May through October 31. When February, March and April forecasts project an EOA storage of 3.0–3.7 MAF, water temperatures of 53.5 will be managed at the CCR gauge from May through October 31, and when February, March and April forecasts project an EOA storage of less than or equal to 2.0–3.0 MAF, water temperatures of 53.5 will be managed at some location upstream of the CCR gauge from May through October 31.

7.1.1.2.3.3.2. Central Valley Spring-Run Chinook Salmon Exposure and Response

7.1.1.2.3.3.2.1. Out-Migration Cues

The proposed Sacramento River Pulse Flows (Section 3.1.7 in U.S. Bureau of Reclamation 2023-2024) is intended to coincide with the migration timing of juvenile CV spring-run Chinook salmon. Juvenile CV spring-run Chinook salmon migration into the Delta begins in winter and continues through early May, ending just before the end of the spring pulse flow period. Specifically, based on the 10 years of Knights Landing rotary screw trap data, March 1 corresponds to a median date of CV spring-run Chinook salmon passage at Knights Landing of about 25 percent. Therefore, depending on when a pulse flow is implemented, up to 75 percent of the juvenile CV spring-run Chinook salmon of a year's cohort would be exposed to conditions of a spring pulse flow. Overall in-river survival under the proposed action is modeled to range from about 11 to 26 percent, with the lowest survival rates in critical years and the highest in wet years (

Table 21).

As proposed, a pulse flow occurring in the spring is expected to result in increased survival of juvenile salmonids by mimicking the natural hydrologic cues that trigger salmonid out-migration (Kjelson et al. 1981). The proposed action does not specify what years the pulse flows will be implemented in, but it would presumably be more difficult to implement in critical water years (about 15 percent of the record) and likely less impactful in wet water years (about 18 percent of the record), so the remaining two-thirds of years would be most likely years for implementation.

Species response to a spring pulse would be decreased travel times for juveniles, affecting survival (improved out-migration cues for juveniles and yearlings), and a temporary increase in riparian habitat accessibility (improved refuge habitat). For juveniles and yearlings, there is an

expected increase in survival across water year types. A flow threshold model was used to evaluate the effects of flow changes in the proposed action on the Sacramento River on juvenile Chinook salmon out-migration. This analysis relies on established flow-survival relationships (Michel et al. 2021) applied specifically to the Sacramento River at Wilkins Slough. The model focuses on the spring out-migration period (March 15–June 15). It predicts the annual mean probability of juvenile Chinook salmon survival within the Sacramento River section between Deer Creek and Feather River confluences. The annual mean survival estimate is calculated by aggregating daily survival predictions.

Additionally, pulse flows can alter river temperatures, thereby mimicking natural spring conditions and potentially signaling to juveniles the timing or direction for downstream migration. There are some indications that the combination of pulse flows and temperature cues may encourage the movement of CV spring-run Chinook salmon into cooler habitat in their adult migratory life stage. For example, in the spring of 2021, robust upstream movement of CV spring-run Chinook salmon during the pulse flow on Clear Creek also coincided with the tributary being about 9°F cooler than the mainstem Sacramento River, although further analysis, including video monitoring and temperature data, is needed to understand this relationship (Clear Creek Technical Team 2021). Specific to juvenile life stages, research on Chinook salmon in the Columbia River indicated a strong temperature preference during smoltification for fall-run Chinook salmon, but not CV spring-run Chinook salmon, potentially because the system lacked a large temperature gradient during the spring-run Chinook salmon's earlier out-migration period to help orient the fish in their downstream movement (Sauter et al. 2001).

Under the proposed action (Alt2v1), the average mean annual seasonal survival ranges from about 11 to 26 percent, and under the NAA it ranges from about 6 to 25 percent while under EXP3 it ranges from approximately 6 to 24 percent (

Table 21). The drier the water year, the more effective this action is expected to be, although the water cost may be higher as well since the pulses might not be able to be combined with flood control releases, high natural inflow, or VA assets. Additionally, the hydrologic alteration used to capture many natural spring pulses for storage is expected to reduce yearling's out-migration cues, rates and survival, even if that storage is later used to mimic a pulse flow. Under existing conditions, the capturing of water behind Shasta and Keswick dams is detrimental to CV spring-run Chinook salmon out-migration cues and only partially mitigated by the proposed managed pulses.

Table 21. Average mean annual seasonal survival percent for different modeled scenarios by water year type for the proposed action (Alt2v1), no action alternative (NAA), and EXP3.

Water Year Type	Proposed Action (Alt2v1)	NAA	EXP3
Wet	26.12	24.91	24.04
Above Normal	20.95	19.83	17.78
Below Normal	16.42	15.20	12.47
Dry	14.42	12.08	9.94
Critical	11.14	5.87	5.71

Source of information: Appendix J, Attachment J, Table 2 in (U.S. Bureau of Reclamation 2023-2024)

Studies have used acoustic tags to track fall-run Chinook salmon juveniles as a surrogate for out-migrating CV spring-run Chinook salmon as they migrate down the Sacramento River from Red Bluff Diversion Dam to Tower Bridge in Sacramento (CalFish Track 2024). Using Cormack-Jolly-Seber survival models, the studies initiated in April of the respective years observed a range of survivals. Since these studies might miss fish that take a detour through the Yolo Bypass floodway during high water, the reported survival rates (about 33 percent in 2024, 25 percent in 2023, and 5 percent in 2022) are likely underestimates of actual survival (

Table 22).

Table 22. Central Valley spring-run Chinook salmon (fall-run Chinook salmon surrogate) Upper Sacramento River basin minimum survival to Tower Bridge (using the Cormack-Jolly-Seber survival model).

Year	Survival (%)	95% Lower Confidence Interval (%)	95% Upper Confidence Interval (%)
2022	5.1	3.6	7.2
2023	24.5	20.4	29.1
2024	32.9	30	36.1

Source: (CalFish Track 2024)

The severity of the stressor is sublethal (delayed out-migration), the proportion of the population exposed is large (since the Sacramento River is a central migratory corridor for CV spring-run Chinook salmon), the frequency of exposure is high (affecting flows in most water years, and particularly in the two-thirds of dry, below normal and above normal years when flows are less driven by limited reservoir storage or mandatory flood control releases), the magnitude of effect is high, and the weight of evidence is medium.

7.1.1.2.3.3.2.2. Water Temperature, Pathogens, and Disease

CV spring-run Chinook salmon migrate from the ocean up the Sacramento River in the spring to reach spawning areas in the summer and then hold in cold pools until they spawn in the fall. Excessive temperatures can stress adult holding and spawning by decreasing gamete viability, shifting the initiation of spawning, slowing or blocking migration, increasing disease, and potentially interacting with other physiological stressors, such as thiamine deficiency. Under the proposed action, from April through October, averaged across all years, about 3 percent of months at Keswick Dam and 23 percent of months at Redd Bluff Diversion Dam will be above the 59.9°F pathogen virulence water temperature threshold for adult spring-run Chinook salmon migration (Tables 11 and 12 in U.S. Bureau of Reclamation 2023-2024). During critical years, this impact is substantial, exceeding the temperature threshold in 17 percent of months at Keswick Dam and 59 percent of months at Red Bluff Diversion Dam. This substantial impact at

Red Bluff Diversion Dam in critical years is still less than the NAA (31 percent) and EXP3 (45 percent).

Under the proposed action, from April to October, 7 percent of months at Keswick Dam and 96 percent of months at Red Bluff Diversion Dam will be outside the 42.1°F to 55°F optimal water temperature range for minimal adult CV spring-run Chinook salmon migration impairment. These temperatures at Keswick Dam are slightly better than under the NAA (10 percent) but nearly the same as EXP3 (6 percent). At Red Bluff Diversion Dam, the results are the same as the NAA (96 percent) and EXP3 (99 percent). Note that the proposed action describes spring temperatures operations under which, "It is possible that high air temperatures and/or an intentional warm-water power bypass could cause warmer temperatures than normal and may require additional protective measures" (U.S. Bureau of Reclamation 2023-2024). Although the proposed action does not specify the specific conditions for implementation, the action has taken place in recent years (2021), and based on the description in the proposed action, including the measures to minimize effects, it is reasonably certain to occur. The increased temperatures during this period from a warm water power bypass, to improve summer and fall conditions, could negatively impact spring time water temperatures to the detriment of adults. This action is analyzed under the drought toolkit along with other adaptive management tools. Warm water bypasses are not listed in the modeling assumptions for the Sacramento River (Appendix F: Modeling, Section 1-1 in U.S. Bureau of Reclamation 2023-2024). From 1906 to 2022, the Sacramento Valley Water Year Type has been dry or critical 36 percent of the time. In light of ongoing climate change, looking at just the more recent period, 2002-2022, shows an even higher frequency, with 48 percent of the water years dry or critical. Therefore, the frequency for the impacts are classified as medium for this analysis. In summary, the impact is lethal (the result of chronic temperatures above the optimal range), the proportion of the population exposed is large (since the Sacramento River is a central migratory corridor for CV spring-run Chinook salmon), the frequency of exposure is high (with impacts in nearly all water years), the magnitude of effect is high, and the weight of evidence is medium (supported by temperature and some fish monitoring data to quantify the exposure).

Under the proposed action, from April through December, 95 percent of months at Keswick Dam and 27 percent of the months at Red Bluff Diversion Dam are projected to be outside the optimal 55.4°F to 68°F water temperature range for successful yearling rearing of spring-run Chinook salmon (Tables 20 and 21 in U.S. Bureau of Reclamation 2023-2024). Averaged across all years, these modeling outcomes are largely similar to the results anticipated under NAA and EXP3 at both locations (within 1 to 4 percent). The severity of the stressor is lethal (water temperatures outside the optimal range for yearlings can disrupt physiological processes, increase susceptibility to disease, and ultimately lead to death), the proportion of the population exposed is small (since a larger proportion of rearing occurs on tributaries), the frequency of exposure is high (impacted in all years), the magnitude of effect is medium, and the weight of evidence is medium (based on the provided HEC-5Q monthly temperature modeling results).

Under the proposed action, the percent of months above the 59.9°F pathogen virulence water temperature threshold for adult CV spring-run Chinook salmon migration from April through October will exceed the target 3 percent of months at Keswick Dam and 23 percent of months at Red Bluff Diversion Dam (Tables 11 and 12 in U.S. Bureau of Reclamation 2023-2024). At Keswick Dam, 17 percent of months will exceed the threshold in critical years, compared to 15 percent under the NAA and 5 percent under EXP3. At Red Bluff Diversion Dam, 59 percent of

months will be above the threshold in critical years, compared to 68 percent of months under the NAA and 70 percent of months under EXP3. Although the BA suggests there is also a beneficial effect in other water years, the aforementioned line of evidence does not support this conclusion. The severity of the stressor is lethal (water temperatures outside the optimal range for adult migration can disrupt physiological processes, increase susceptibility to disease, and ultimately lead to death), the proportion of the population exposed is small (since a larger proportion of spawning occurs on tributaries), the frequency of exposure is high (impacted in some years at Keswick Dam and at years at Red Bluff Diversion Dam), the magnitude of effect is medium, and the weight of evidence is medium (based on the provided HEC-5Q monthly temperature modeling results).

7.1.1.2.3.3.2.3. Spawning Habitat, Stranding, and Dewatering

Similar to the effects to SR winter-run Chinook salmon, juvenile stranding generally results from reductions in flow that occur over short periods of time, and analytical planning tools cannot predict with certainty the level of effect of possible stranding on fish. Yearling rearing and migration are also expected to experience impacts to stranding due to the proposed storage and release of water, although it will be variable across water year types. Juvenile stranding tends to be minimized through ramping rates. Additionally, the spring period when pulse flows may be implemented also overlaps with adult CV spring-run Chinook salmon upstream migration in March–September (Yoshiyama et al. 1998), so these spring pulses are also expected to have the beneficial effects of reducing water temperatures during the spring and improving adult passage.

Based on modeling of potential juvenile stranding for CV spring-run Chinook salmon fry rearing in the Sacramento River from Keswick Dam to the Battle Creek confluence, the proposed action is expected to result in the stranding of 7,916 individuals (Table 23). This stranding is projected to be highest in wet years (9,354 individuals) and lowest in critical years (6,703 individuals). Averaged across all years, there are anticipated to be 8,213 individuals under NAA and 8,199 under EXP3. These modeling results represent stranding potential and, therefore, are most useful in a comparative analysis, which indicates about a 3-percent decrease under the proposed action relative to NAA and EXP3. The severity of the stressor is lethal (stranding leaves juveniles vulnerable to suffocation, predation, and temperature extremes, ultimately leading to death if they cannot return to flowing water), the proportion of the population exposed is medium (the upstream reach of the Sacramento River especially impacted by Shasta Dam operations serves as rearing habitat for a proportion of juveniles), the frequency of exposure is high (with effects in all water years), the magnitude of effect is high, and the weight of evidence is medium (model results indicate stranding potential, not absolute stranding results).

Table 23. Potential juvenile stranding (number of individuals) for Central Valley spring-run Chinook salmon fry rearing in the Sacramento River from Keswick Dam to the Battle Creek confluence for the proposed action (Alt2v1), no action alternative (NAA), and EXP3.

Water Year Type	Proposed Action (Alt2v1)	NAA	EXP3
Wet	9,354	9,639	11,335
Above Normal	8,632	8,837	9,226

Water Year Type	Proposed Action (Alt2v1)	NAA	EXP3
Below Normal	7,250	7,231	6,542
Dry	7,087	7,422	6,726
Critical	6,703	7,384	5,787
All	7,916	8,213	8,199

Source of information: Appendix L – Shasta Cold Water Pool Attachment L, Table X-6 in (U.S. Bureau of Reclamation 2023-2024)

With relation to the stressors of spawning habitat, NMFS considers that the managed changes in the hydrograph can reduce access to riparian habitat and instream cover both in the immediate area of releases and further downstream (e.g., less frequent inundation of side channels). These changes can reduce accessibility to habitat that may support successful out-migration survival by providing rearing areas, refuge, or increased food availability. Under the proposed action, the expected WUA for CV spring-run Chinook salmon spawning in the Sacramento River from Keswick Dam to the Battle Creek Confluence ranges from about 343,000 in wet years to about 448,000 in critical years, with an average of about 400,000 across all years modeled. There is minimal change (<1 percent averaged across all water years) in spawning habitat as measured by WUA, relative to NAA, but a 12-percent decrease relative to EXP3 (Appendix O, Attachment XX, Sacramento River Weighted Usable Area Analysis, Table X-17 in U.S. Bureau of Reclamation 2023-2024). However, the magnitude of the effect is low, because of low exposure, specifically with only a remnant spawning population of CV spring-run Chinook salmon in the Sacramento River. Therefore, in summary, the severity of the stressor is lethal, the proportion of the population exposed is small, the frequency of exposure is low, the magnitude of effect is low, and the weight of evidence is medium.

For yearling rearing and migration, increased mortality from stranding due to the proposed storage and release of water is expected under the proposed action, although impacts are variable across water year types. Based on modeling of potential juvenile stranding for CV spring-run Chinook salmon fry rearing in the Sacramento River from Keswick Dam to the Battle Creek confluence, the proposed action is expected to reduce stranding by 6 to 17 percent in relatively wetter (wet and above normal) years. However, it is expected to increase stranding by 5 to 16 percent in drier (below normal, dry and critical) years (Table 23). The severity of the stressor is lethal (stranding leaves juveniles vulnerable to suffocation, predation, and temperature extremes, ultimately leading to death if they cannot return to flowing water), the proportion of the population exposed is medium (the upstream reach of the Sacramento River especially impacted by Shasta Dam operations serves as rearing and migration habitat for a proportion of CV spring-run Chinook salmon), the frequency of exposure is high (with effects in all water years), the magnitude of effect is high, and the weight of evidence is medium (model results indicate stranding potential, not absolute stranding results).

7.1.1.2.3.3.2.4. Refuge Habitat and Food Availability and Quality

With relation to the stressors of Refuge Habitat and Food Availability and Quality, NMFS considers that the managed changes in the hydrograph can reduce access to riparian habitat and instream cover in the immediate area of releases, but perhaps more so further downstream (e.g., less frequent overtopping of Fremont Weir and access to Yolo Bypass habitat). Decreased flows in the Sacramento River can both reduce suitable margin and off-channel habitats available as refuge habitat for juveniles.

Juvenile spawning habitat in the Upper Sacramento River was calculated using HEC-RAS instream and floodplain flow-habitat curves (Appendix O, U.S. Bureau of Reclamation 2023-2024). Habitat estimates, calculated for each month and relevant to specific salmon runs and life stages, were expressed in the estimates as acres for consistency across different models and watersheds, despite some debate about the appropriateness of using area units. The results showed that spawning habitat for spring-run in the Upper Sacramento River increases slightly from September to October for all alternatives, however spawner ratios much less than one indicated that spawning habitat may not be limiting (Table 9, Figures 13 and 14 in Appendix O, U.S. Bureau of Reclamation 2023-2024). Based on the results from the aforementioned modeling, the proposed action will support between approximately 31 and 60 acres of instream shallow-water rearing habitat along the upper Sacramento River from Keswick Dam to Battle Creek, with the lowest acreage in July and the highest in October, and approximately 0.5 to 56 acres of floodplain habitat with the lowest acreage in October and the highest in February (Tables 24 and 25 in U.S. Bureau of Reclamation 2023-2024).

The proposed action is expected to alter habitat for CV spring-run Chinook salmon rearing in the Sacramento River from Keswick Dam to the Battle Creek confluence a minimal amount (one or less acres) compared to the NAA. In relation to EXP3, the expected habitat is anticipated to decrease by 7 percent for fry and 2 percent for juveniles (Appendix O, Attachment XX, Tables X-19 and X-21 in U.S. Bureau of Reclamation 2023-2024). There is also a decrease in the predicted mean rearing habitat quantities, in acres, for CV spring-run Chinook salmon in the Upper Sacramento River. When averaged across all water years and summed across all months, modeling predicts a total loss of 62 acres of instream rearing (9-percent decrease) and 31 acres of floodplain rearing habitat (18-percent decrease; Appendix O, Attachment X, Tables 24 and 25 in U.S. Bureau of Reclamation 2023-2024). Although there are predicted increases in instream rearing habitat from December through March, they were outweighed by decreases for the rest of the year, most of all in July (Table 24). Similarly, predicted increases in floodplain rearing habitat in March and May–September were more than offset by decreases during the rest of the year, particularly February (Table 24).

Table 24. Predicted mean instream and floodplain rearing habitat quantities, in acres, for juvenile Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and California Central Valley steelhead in the Upper Sacramento River rounded to the nearest tenth of an acre.

	Instream rearing (acres)			Floodplain rearing (acres)		
Month	Proposed Action (Alt2v1)	NAA	EXP3	Proposed Action (Alt2v1)	NAA	EXP3
January	52.8	54.1	51.6	28.7	27.7	31.6

	Instream rearing (acres)			Floodplain rearing (acres)		
Month	Proposed Action (Alt2v1)	NAA	EXP3	Proposed Action (Alt2v1)	NAA	EXP3
February	48.5	49.0	47.7	55.9	55.6	61.5
March	53.2	53.6	52.6	22.2	22.4	21.9
April	56.7	57.1	62.0	4.0	4.1	6.0
May	50.3	49.8	54.7	1.6	1.7	1.1
June	42.4	41.5	55.1	3.4	3.5	0.3
July	31.2	30.5	48.8	6.7	6.8	0.6
August	42.9	42.2	56.0	2.7	2.9	0.0
September	56.8	56.8	66.8	0.9	0.8	0.3
October	60.7	60.9	69.2	0.5	0.5	0.9
November	58.7	60.1	67.7	0.8	0.8	1.1
December	55.0	55.5	40.3	12.3	11.9	44.7

Source: Appendix O, Attachment X, SIT LCM Habitat Estimates, Tables 24 and 25 in (U.S. Bureau of Reclamation 2023-2024)

The decrease in Fremont Weir Spills and Yolo Bypass long-term average flows (Appendix F: Modeling Section 1-1, Figures F.2.2-10-1 and F.2.2-11-1 in U.S. Bureau of Reclamation 2023-2024) will also reduce downstream habitat for juveniles. These impacts will affect juvenile rearing to out-migration, yearling rearing, and migration life stages. The severity of the stressor is sublethal, the proportion of the population exposed is large (since the Sacramento River is a central out-migratory corridor for CV spring-run Chinook salmon juveniles), the frequency of exposure is low (with minimal relative differences in most years), the magnitude of effect is medium, and the weight of evidence is high (based on multiple habitat modeling results).

7.1.1.2.3.3.3. California Central Valley Steelhead Exposure and Response

7.1.1.2.3.3.3.1. Stranding Risk

Juvenile CCV steelhead face the risk of stranding during the spring operations seasons as a result of variable release conditions that could strand fish in shallow water or along near-shore gravel bars. Stranding tends to be lowest in critical and dry years and peaks in wet years. The high level of stranding in wet years is expected because fry rear from mid-winter through mid-spring when storms and high runoff increase flow fluctuations, which tends to result in higher levels of stranding.

Modeling anticipates variable impacts of the proposed action on juvenile CCV steelhead stranding in the Sacramento River from Keswick Dam to Battle Creek, depending on the water year type ranging from a low of 3,544 individuals in dry years to 7,973 in wet years and averaging 5,277 individuals across all water year types (Table 20). Averaged across all years, the proposed action stranding will be 6 percent less than the NAA (5,636 potential juveniles stranded) and 2 percent less than EXP3 (5,398 potential juveniles stranded). The majority of the stranding is anticipated to occur in February and March, relative to April and May (Figure 53).

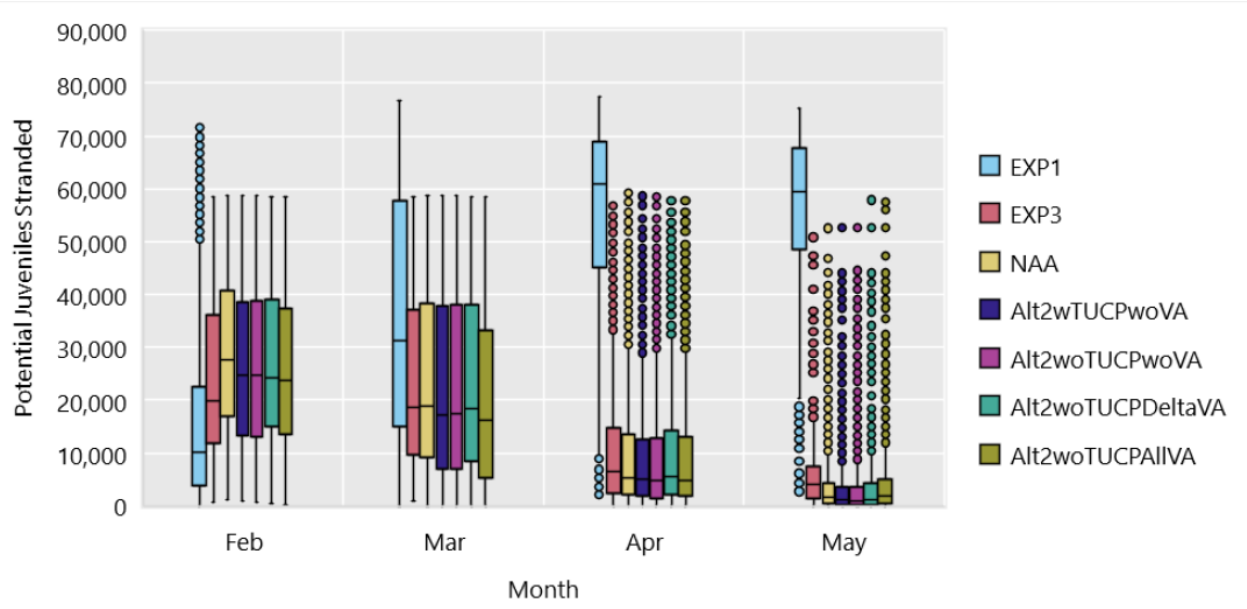


Figure 53. Potential juvenile stranding for California Central Valley steelhead in the Sacramento River from Keswick Dam to the Battle Creek confluence for all modeling scenarios (EXP1, EXP3, the NAA, and four phases of Alternative 2), by month.

Source: LTO Appendix L – Shasta Cold Water Pool Attachment L, Figure X-9 in (U.S. Bureau of Reclamation 2023-2024)

The severity of the stressor is lethal, the proportion of the population exposed is medium (the upstream reach of the Sacramento River especially impacted by Shasta Dam operations serves as rearing habitat for a proportion of CCV steelhead yearlings and young of year), the frequency of exposure is high (with effects in all water years), the magnitude of effect is high, and the weight of evidence is medium (model results indicate stranding potential, not absolute stranding results)

7.1.1.2.3.3.3.2. Refuge Habitat

With relation to the stressors Refuge Habitat and Food Availability and Quality, NMFS considers that the managed changes in the hydrograph can reduce access to riparian habitat and instream cover both in the immediate area of releases and further downstream (e.g., less frequent inundation of side channels). These changes can reduce accessibility to habitat that may support successful out-migration survival by providing rearing areas, refuge, or increased food availability. Refuge habitat is influenced by spring flows that tend to be variable between mid-winter and mid-September. We anticipate critical and dry water years will have relatively less

refuge habitat than in above normal and wet years, when higher flows will inundate habitats in side channels and increase the amount of shallow water habitat available for rearing and growth.

The expected WUA for CCV steelhead juvenile rearing in the Sacramento River from Keswick Dam to the Battle Creek confluence is 732,222 under the proposed action, which is about 1 percent less than under NAA (738,999) and 2 percent less than under EXP3 (749,835; Appendix O, Attachment XX, Table X-12 in U.S. Bureau of Reclamation 2023-2024). The severity of the stressor is sublethal, the proportion of the population exposed is medium (the upstream reach of the Sacramento River especially impacted by Shasta Dam operations serves as rearing habitat for a proportion of CCV steelhead yearlings and young of year), the frequency of exposure is medium (with measurable effects in a portion of the years, particularly wetter ones), the magnitude of effect is medium, and the weight of evidence is medium (impacts on foraging and diet are well documented, but the model's design makes it better at showing comparative results (e.g., how much foraging changes compared to a baseline) rather than precise measurements (e.g., exactly how many fewer food items are found).

7.1.1.2.3.3.3.3. Water Temperature

Mortality of incubating eggs can occur due to increased metabolic demand and reduced dissolved oxygen in warmer water. Modeling indicates that the proposed action will generally result in temperatures that are below thresholds for causing adverse impacts to incubating eggs. Under the proposed action, about 46 percent of months (at Keswick Dam) and 54 percent of months (at Red Bluff Diversion Dam) will be greater than the 45°F to 52°F optimal egg incubation water temperature range for CCV steelhead, for all years combined in December through June (Tables 42 and 43 in (U.S. Bureau of Reclamation 2023-2024), with reweighting of water year types to correct for a mathematical error in averaging in Table 42. Specifically, Table 42 reports that averaged across all water year types, 35 percent of months will not meet the temperature target, but this is less than the range reported for the individual water year types, which vary from 42 to 50 percent. Recalculating based on the water year type frequency results in average across all years of 46 percent).

Compared to NAA, the proposed action is expected to result in less than a 1 percent increase (at both Keswick Dam at Red Bluff Diversion Dam) in the months greater than the 45°F to 52°F optimal egg incubation water temperature range for CCV steelhead, for all years combined in December through June. Compared to EXP3, the proposed action is expected to result in 4 percent (at Keswick Dam) and 2 percent (at Red Bluff Diversion Dam) reductions in the months outside the aforementioned optimal egg incubation water temperature range (Tables 42 and 43 in U.S. Bureau of Reclamation 2023-2024). The severity of the stressor is sub-lethal, the proportion of the population exposed is small (since they primarily spawn in smaller tributaries rather than the mainstem Sacramento River), the frequency of exposure is high (with effects in all water years), the magnitude of effect is medium, and the weight of evidence is high (since this reach of the Sacramento River has temperature gauges and monitoring to determine the magnitude of this stressor).

7.1.1.2.3.3.3.4. Pathogens and Disease

Lower water temperatures are associated with a reduction in the prevalence of pathogens and diseases, potentially improving the fitness and migration success of adult CCV steelhead. Salmonid pathogens and diseases can spread vertically (parent to offspring) or horizontally

(between individuals), as described by Baxa-Antonio et al. (1992). Seasonal water management practices that reduce river flow can concentrate pathogens, facilitating horizontal transmission and rising water temperatures can increase the virulence of pathogens. Research by McCullough (1999) indicates that diseases affecting salmonids become highly virulent at temperatures exceeding 59.9°F (U.S. Bureau of Reclamation 2023-2024).

The proposed action is expected to maintain water temperatures that are below the threshold of 59.9°F for increasing pathogen virulence for most months, with thresholds being exceeded in 13.5 percent months in critical years. This is more than the NAA (12.1 percent of months in critical years) and EXP3 (4.3 percent of months in critical years; Table 10 in U.S. Bureau of Reclamation 2023-2024). Further downstream at Red Bluff Diversion Dam and Hamilton City, these temperature exceedances are 10 and 35 percent, respectively, for the proposed action, a modest increase compared to the NAA (8 and 35 percent, respectively), and lower than in EXP3 (16 and 39 percent, respectively; Table 25 in U.S. Bureau of Reclamation 2023-2024). The severity of the stressor is lethal (elevated water temperatures can increase the susceptibility of CCV steelhead eggs to pathogens, reduce dissolved oxygen levels critical for development, and disrupt embryonic development, leading to mortality), the proportion of the population exposed is small (since they primarily spawn in smaller tributaries rather than the mainstem Sacramento River), the frequency of exposure is low (with effects limited to critical years), the magnitude of effect is low, and the weight of evidence is medium (since this reach of the Sacramento River has temperature gauges and monitoring to determine the magnitude of this stressor).

The relationship for juveniles follows a similar pattern where the percent of months above the 59.9°F pathogen virulence water temperature threshold for juvenile CCV steelhead rearing and out-migration by water year type is expected at Keswick Dam to be unchanged relative to NAA, and increase by 1 percent relative to EXP3, but it will decrease by 6 percent (relative to NAA) and decrease by 12 percent (relative to EXP3) at the Red Bluff Diversion Dam (Tables 59 and 60 in U.S. Bureau of Reclamation 2023-2024). The severity of the stressor is sublethal in the summer, fall and spring, and the proportion of the population exposed is medium in the summer/fall, but small in the spring. The frequency of exposure and weight of evidence for both are medium. As a result, the overall magnitude of the effect is medium for summer/fall and spring. Discussion of the latter impacts are considered under Shasta Spring Operations. Additionally, for kelts, there is an 8-percent increase relative to NAA and a 16-percent decrease relative to EXP3 in months with pathogen virulence water temperatures. This results in 18 percent of months from February through June above the threshold when averaged across all years (Table 36 in U.S. Bureau of Reclamation 2023-2024). The severity of the stressor is lethal, as the BA notes, the “Presence of pathogens and disease may increase stress on steelhead kelts, reducing fitness and impairing emigration. It is uncertain how pathogens and disease may influence rates of anadromy and out-migration cues” (U.S. Bureau of Reclamation 2023-2024). The proportion of the population exposed is medium (the upstream reach of the Sacramento River especially impacted by Shasta Dam operations serves as rearing habitat for a proportion of CCV steelhead), the frequency of exposure is medium (with measurable effects at some, but not all, water years at the locations analyzed), the magnitude of effect is high, and the weight of evidence is medium (supported by temperature and some fish monitoring data to quantify the exposure).

Lastly, for the egg incubation life stage, under the proposed action, 13 percent of months, from December through June, will be above the 59.9°F pathogen virulence water temperature

threshold for CCV steelhead egg incubation and fry emergence, averaged across all years for the Sacramento River at the Red Bluff Diversion Dam. This is lower than the impact anticipated under the NAA (18 percent) and EXP3 (24 percent, Table 49 in U.S. Bureau of Reclamation 2023-2024). It is higher, however, than the impact for the same metric at Keswick Dam, which was not anticipated to be exceeded in any of the months for either the proposed action, NAA, nor EXP3 (Table 48 in U.S. Bureau of Reclamation 2023-2024). The severity of the stressor is lethal, the proportion of the population exposed is small (the upstream reach of the Sacramento River especially impacted by Shasta Dam operations serves as a small amount of spawning habitat for CCV steelhead), the frequency of exposure is high (with effects in most water years), the magnitude of effect is medium, and the weight of evidence is high (supported by temperature data to quantify the exposure).

7.1.1.2.3.3.3.5. Spawning Habitat

The expected WUA for CCV steelhead spawning habitat from Keswick Dam to Battle Creek ranges substantially between water years, from a low of approximately 68,889 in wet years to a high of 120,229 in critical years. This is nearly identical to the NAA, which ranges from 68,940 to 120,314, as well as EXP3, which ranges from 68,022 to 120,505. Therefore, there is minimal variation between these modeled alternatives in predicted mean spawning habitat quantities for adult CCV steelhead in the Upper Sacramento River (Table 4 in U.S. Bureau of Reclamation 2023-2024). The severity of the stressor is sub-lethal, the proportion of the population exposed is small, the frequency of exposure is low, the magnitude of effect is low, and the weight of evidence is medium.

7.1.1.2.3.3.3.6. Food Availability and Quality

Sacramento River natal and mainstem young-of-year rearing are at their highest annual abundance for CCV steelhead during the springtime (Figure 16 in U.S. Bureau of Reclamation 2023-2024). Decreased quality and quantity of food due to flow alterations for foraging juvenile CCV steelhead will impact growth rates. Specifically, decreases in the frequency of high springtime flows could decrease food availability and quality for juvenile CCV steelhead on the Sacramento River. High spring flows allow juvenile CCV steelhead to access nutrient-rich floodplains. Floodplain activation and high flows also stimulate the growth of aquatic and terrestrial invertebrates that form the base of the CCV steelhead diet. When food is scarce due to limited floodplain access and invertebrate production, juvenile CCV steelhead will face increased competition from other fish species. This can lead to stunted growth and poor overall condition. Lower flows can also lead to warmer water temperatures. Warm water promotes the growth of algae and other aquatic plants. These changes impact the composition of the food web, potentially favoring less nutritious food sources for CCV steelhead. Finally, high flows carry insects and other food items downstream to where juvenile CCV steelhead are rearing.

With less frequent high flows, this transport mechanism is diminished, reducing food availability. Modeling indicates that Sacramento River median December flows at Bend Bridge under the proposed action (7,412 cfs) will be roughly equivalent to NAA (7,347 cfs), but is less than half of the flows expected under EXP3 (16,845 cfs, see Appendix F, Figure F.2.2-4-9 in (U.S. Bureau of Reclamation 2023-2024). The lack of higher flows will impact conditions downstream, for example, by reducing the entrainment of juveniles and yearlings into floodplain habitat, such as the Yolo Bypass (Appendix F, Figures F.2.2-10-1 and F.2.2-11-1 in U.S. Bureau of Reclamation 2023-2024). The severity of the stressor is sublethal, the proportion of the

population exposed is large, the frequency of exposure is low, the magnitude of effect is medium, and the weight of evidence is high.

7.1.1.2.3.3.3.7. Out-Migration Cues

Although relatively small run sizes have limited the number of direct observations, the Knights Landing rotary screw trap data from the last 15 years show a large proportion of juvenile CCV steelhead in the Lower Sacramento River from March 1 to May 15. These fish would experience the effects of a spring pulse flow that would facilitate their out-migration. By March 1, 25 to 50 percent of juvenile CCV steelhead will have passed Knights Landing, migrating into the Delta. Depending on when a pulse flow is implemented, up to 50 to 75 percent of the CCV steelhead juveniles of a year's cohort would be exposed to conditions of a spring pulse flow. Given the uncertainty of actual forecasting, we assume the May 1 Shasta storage of 4 MAF would occur less frequently than the 75 percent probability provided in the modeling.

Similar to other species, CCV steelhead response to a spring pulse would be a decreased travel time for juveniles, improving survival (improved flow conditions), and a temporary increase in riparian habitat accessibility (improved refuge habitat). The spring pulse period does not overlap significantly with adult CCV steelhead migration, which occurs predominantly from July through December (McEwan 2001).

Under the proposed action, 41 percent of months from January through May, averaged across all years, will be above the 55°F water temperature threshold for the juvenile CCV steelhead out-migration cue in the Sacramento River at the Red Bluff Diversion Dam (Table 66 in U.S. Bureau of Reclamation 2023-2024). This is nearly identical to the frequency of exceedances under the NAA (41 percent of months) and marginally less than the frequency under EXP3 (43 percent of months). The impact under the proposed action would be particularly severe during critical years when nearly half (48 percent) of the months would be above the threshold, so that young CCV steelhead may miss critical environmental cues that trigger their downstream migration, leading them to delay or even forgo their journey to the ocean. Therefore, the severity of the stressor is sub-lethal (primarily delayed out-migration), the proportion of the population exposed is large, the frequency of exposure is low, the magnitude of effect is medium, and the weight of evidence is medium.

7.1.1.2.3.3.4. Southern Distinct Population Segment of Green Sturgeon Exposure and Response

7.1.1.2.3.3.4.1. Egg Incubation and Migration Cues

Adult sDPS green sturgeon migrate upriver from March to early April, and spawn from April through July, with median spawning in May (Poytress et al. 2015, Figure 3 in U.S. Bureau of Reclamation 2023-2024). Adult sDPS green sturgeon migration and spawning timing is such that a large proportion of sDPS green sturgeon are expected to be in the mainstem Sacramento River from March through July (Poytress et al. 2015). The proposed spring pulse flow would occur from March 1 to May 15, if implemented.

The timing of adult sDPS green sturgeon migration often coincides with high Delta outflow in the spring. Therefore, reductions in late-winter and spring months flows that affect Delta outflow in February and March could impact spawning migration cues. While changes in low flows are unlikely to influence the frequency, magnitude, or duration of the higher flows to which sturgeon

respond, we consider that the managed changes in the hydrograph can reduce the strength of the seasonal spawning migration cues.

Because the spring pulse flow would better characterize the natural hydrograph for the Sacramento River, adult sDPS green sturgeon would be expected to experience periods during which the spring pulse flow would mitigate the effects of the otherwise altered hydrograph resulting from the proposed action. For the years a spring pulse flow occurs, we expect temporarily improved conditions conducive to spawning and migration by reducing passage impediments to migration and increasing the frequency of high flow events, which are otherwise limited.

As noted in the BA, "green sturgeon embryo hatching success is maximized between 57.2 - 62.6°F and acceptable between 52 - 63°F" (U.S. Bureau of Reclamation 2023-2024). The percent of months from April through July outside the 52.3°F to 60.8°F water temperature range supporting sDPS green sturgeon egg incubation at Bend Bridge will be 3 percent under the proposed action, 5 percent under NAA, and 8 percent under EXP3. There is not a strong correlation with water year type as the highest impact under the proposed action is anticipated during wet years (9 percent), the lowest in above and below normal years (0 percent), and small impact in dry and critical years (1 to 2 percent, Tables 4 and 5 in U.S. Bureau of Reclamation 2023-2024). The severity of the stressor is sub-lethal, the proportion of the population exposed is large (the Sacramento River is central spawning location for sDPS green sturgeon), the frequency of exposure is medium (impactful in wet years, less so in dry and critical years, and not at all in above and below normal years), the magnitude of effect is medium, and the weight of evidence is high (supported by temperature monitoring and sturgeon spawning survey data to quantify the exposure).

For sDPS green sturgeon larvae, the BA (U.S. Bureau of Reclamation 2023-2024) summarizes that, "In laboratory studies, water temperatures greater than 64.4°F (18°C) have been found to be detrimental to newly hatched larvae, with notochord deformities occurring between 68°F and 78.8°F (20°C and 26°C, Linares-Casenave et al. 2013). Post yolk-sac larvae exhibited accelerated growth at higher temperatures 75.2°F (24°C) when food was maintained in the lab. In the field, yolk-sac larvae have been collected between 55.2 and 55.8°F (12.9 and 13.2°C, Poytress et al. 2015), but temperatures are held at approximately 56°F in these areas. Zarri et al. (2019) noted that warmer temperatures were associated with fuller stomachs and improved body condition but did not indicate an optimal temperature."

Under the proposed action, 5 percent of months from May through August will be above the 64.4°F upper water temperature limit for newly hatched sDPS green sturgeon larvae during critical years at Bend Bridge (Tables 6 and 7 in U.S. Bureau of Reclamation 2023-2024). This is the same exceedance frequency as under NAA, but more than under EXP3, which anticipates no exceedances. Downstream at Hamilton City, impacts are anticipated not just during critical years, but across all water year types. Under the proposed action, the months in exceedance of the temperature limit are anticipated to average 35 percent (ranging from 26 percent in dry years to 66 percent in critical years). This is relatively similar to conditions under the NAA, which average 39 percent (ranging from 29 percent in above normal years to 70 percent in critical years). The anticipated exceedances under EXP3, however, are much higher, averaging 73 percent (ranging from 62 percent in dry years to 81 percent in critical years). The severity of the stressor is lethal, the proportion of the population exposed is large (the Sacramento River is central spawning location for sDPS green sturgeon), the frequency of exposure is medium

(impacts are limited to Critical years at Bend Bridge, but are widespread at Hamilton City), the magnitude of effect is medium, and the weight of evidence is medium (supported by temperature monitoring and sturgeon spawning survey data to quantify the exposure).

7.1.1.2.4. Shasta Summer Operations

Water temperatures significantly affect the distribution, health, and survival of native salmonids in the California Central Valley. Since salmonids are ectothermic, their survival is dependent on external water temperatures and they will experience adverse health effects when exposed to temperatures outside their optimal range. Throughout year-round operations, physical processes drive relationships between flows, storage, cold water pool volume, and water temperatures (both reservoir and in-river). These relationships are driven by meteorology, precipitation, infiltration, runoff, and solar radiation, as well as Reclamation's actions and those of the water contractors included in the proposed action and all other diversions. Because of the thermal dynamics associated with seasonal stratification in Shasta Reservoir, Reclamation's decision concerning storage levels are linked to cold water pool volume availability and are primarily driven by hydrology, though meteorology also plays a role. As such, Reclamation's management of reservoir storage and operation of the temperature control device throughout the year impacts the availability of cold water and release temperatures and the subsequent thermal dynamics of the mainstem Sacramento River.

7.1.1.2.4.1. Water Temperature and Storage, Egg Incubation, and Emergence Temperature Objectives

Shasta Reservoir is the largest reservoir in the CVP and the state of California and is operated to best meet all the authorized purposes of the reservoir to maximize the beneficial use of inflow and provide flood protection for the Sacramento River. However, climate change is making this task more difficult. Droughts are becoming more frequent and severe, with less rain and snowmelt refilling the reservoir. Due to climate change, Shasta Reservoir's watershed is anticipated to have significantly less inflow, higher evaporation and evapotranspiration due to increased temperature and more extreme hydrological and meteorological events. These factors combine to exacerbate threats to the Sacramento River's endangered anadromous fish species, which are already stressed by multiple challenges.

In response, Reclamation is proposing an approach that considers drought protection actions nearly every year and identifies actions that will protect storage for multiple project purposes, including temperature management. This approach acknowledges the near-constant threat of drought and that drought protection and fish protection go hand-in-hand. The approach borrows from strategies developed in Victoria, Australia, during a recent multi-year drought (Mount et al. 2016, "Victorian Objectives"). It outlines different management approaches based on water availability to achieve explicit biological objectives. During wetter water years, the focus is on enhancing fish habitats. In drier years, the goal becomes recovering and maintaining these habitats, and in severe droughts, simply protecting habitats becomes the priority. The approach is documented in a Shasta Reservoir Management Plan (Shasta Management Plan) that will use a system of management "Bins" to develop a TMP to administer water temperature and storage levels (Figure 54). There are three Bins (1, 2, and 3) based on the expected EOA storage. Each Bin has two categories: A (standard) and B (drought protection). As the proposed action describes (U.S. Bureau of Reclamation 2023-2024), the letter of the Bin (A or B) is primarily

driven by the expected demands on the reservoir which are a function of hydrology, meteorology, system-wide conditions, contractual requirements and other conditions. The A Bins are years when the expected demand on the reservoir is lower, meaning it is likely to result in better drought protection should the following year be dry. The B Bins are intended to increase the priority of storage conservation to address the possibility that the ensuing year could be a drought. B Bins may be conditions where there is limited water supply in the Shasta system, or the system as a whole is more stressed and additional actions are necessary to reach the objectives of that Bin. A stressed system is typically indicated by multiple reservoirs across the CVP and SWP having below-average storage with below-average hydrology either seasonally or in a particular month (Table 25). Bin assignments will begin in February, and will be updated monthly as needed through mid-April, after which adjustments will require coordination with SHOT. Reclamation will coordinate through the SRG to prepare a draft TMP in April with projected reservoir releases, assumed meteorological conditions, anticipated water temperatures and target locations, and TDM estimates. Reclamation will finalize the TMP in May or later through coordination with the SRG and SHOT. Reclamation may also update the TMP through coordination with the SRG and SHOT.

Modeling indicates that under the proposed action (Alt2v1), the End of September Storage Targets are met 100 percent of the time under the best conditions (18 of 18 Bin 1A years), but 0 percent of the time under the worst (zero out of eight Bin 3B years, U.S. Bureau of Reclamation 2023-2024). There is some correlation between the water year type (i.e., the Sacramento Valley Water Year Index) and the Bin assignments. For example, all Bin 3B years in the modeling record for the proposed action were critical water years. However, there are numerous exceptions to this trend so that even some above normal years, like 2004, would result in a Bin assignment associated with lower reservoir storage under the proposed action (Bin 2A). Conversely, a dry year, like 1948, could result in a bin assignment associated with higher reservoir storage under the proposed action (Bin 1A).

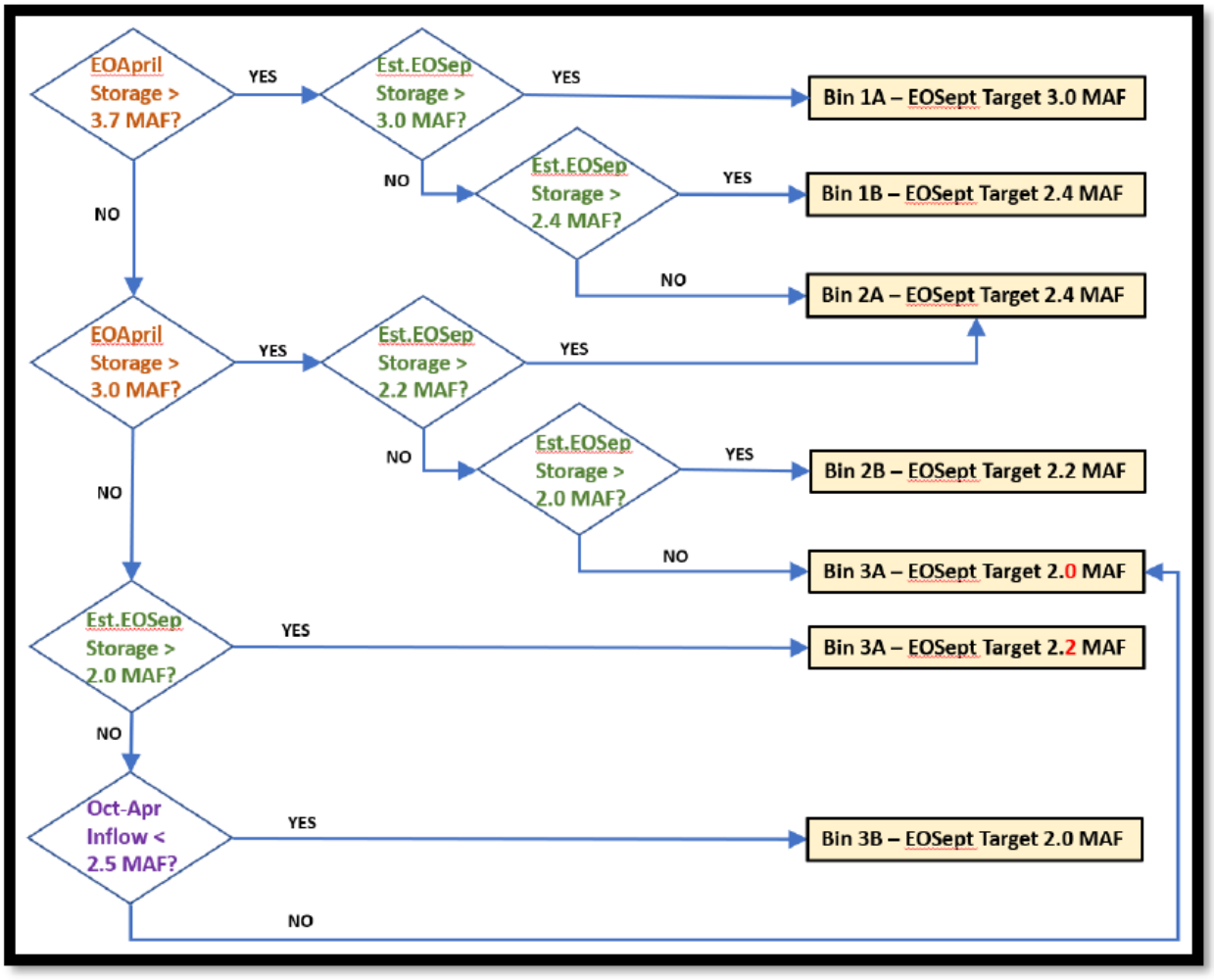


Figure 54. Decision Tree for Shasta Management Bin.

Est. = Estimated; EOApril = End of April; EOSep = End of September; MAF = million acre-feet.

Source: Appendix F, Figure 2 in (U.S. Bureau of Reclamation 2023-2024)

Table 25. Shasta Management Framework Goals, Objectives, and Indicators.

	Bin 1A	Bin 1B	Bin 2A	Bin 2B	Bin 3A	Bin 3B
Estimated Frequency	80% of Years		~11.5% of Years		~8.5% of Years	
Biological Objective	Enhance		Recover	Maintain	Protect	

	Bin 1A	Bin 1B	Bin 2A	Bin 2B	Bin 3A	Bin 3B
Biological Goals	• Maximize species recruitment opportunities • Increase spatial diversity • Maximize floodplain linkages • Enhance ecological flows • Increase available habitat for fall-run Chinook salmon in the fall and winter months		• Maintain or maximize species recruitment opportunities with some reduction in spawning habitat compared to Bin 1 • Maintain or restore river function and key floodplain linkages • Restore key ecological flows		• Avoid critical loss of population • Maintain key refuges of spawning and early rearing habitat • Avoid catastrophic changes to habitat and impacts to the broodyear	
Temperature Management for Sacramento River winter-run Chinook salmon	Manage spawning habitat		Manage the majority of spawning habitat		Manage spawning habitat during the critical periods of the spawning and egg incubation period	
Temperature Target	average daily water temperature of 53.5°F					
Compliance Point	Downstream of the CCR gauge		At the CCR gauge		Upstream of the CCR gauge	
Temperature Dependent Mortality Target	≤3%				≤30%	
EOA (MAF)	≥ 3.7		3.0-3.7		<3.0	
EOS (MAF)	≥ 3.0	≥ 2.4	2.2-2.4	2.0-2.2	>2.0	<2.0
Hydrologic Goal		Initiate drought protection		Increase drought protection		Increase drought protection
Operational Goals		Increase EOS ≥ 2.4 MAF. If impossible, shift into Bin 2A.	Increase EOS >2.2 MAF. If impossible, shift into Bin 2B.	Increase EOS >2.0 MAF. If impossible, shift into Bin 3A.	Increase EOS >2.2 MAF. If impossible shift to Bin 3B.	Increase EOS >2.0 MAF. If impossible identify system priorities and contingencies.

	Bin 1A	Bin 1B	Bin 2A	Bin 2B	Bin 3A	Bin 3B
Operational Goals and Objectives	• Maintain sufficient storage for drought protection should the next year be dry • Limit early season October through December spill to the maximum extent possible • Deliver available water while meeting regulatory requirements and obligations to senior water right holders under the Sacramento River Settlement Contracts				• Maintain and conserve minimal storage to avoid low storages should the next year also be dry • Meet public health and safety demands including Delta salinity standards • Meet obligations to senior water right holders under the Sacramento River Settlement Contracts	

EOA = End-of-April Storage; EOS = End-of-September Storage; MAF = Million Acre-Feet; CCR = Sacramento River Above Clear Creek gauge

Source: summarized from (U.S. Bureau of Reclamation 2023-2024)

As proposed, water temperature management generally occurs from May 15 through October 31; however, start and end dates may be adjusted through coordination with the SRG and SHOT based on SR winter-run Chinook salmon spawning and emergence. Since the Bin determination is intended to be based on the EOA storage value and modeling of anticipated conditions, NMFS notes that there is at least a 14-day period (May 1–14) in which storage may be affected by reservoir releases and inflows. This introduces a component of uncertainty to the ability of the determined Bin operation to meet temperature management objectives later in the management season. Flows are generally in the 7,000 to 8,500 cfs range during these 2 weeks (based on the most recent 10-year average, 2014–2023), but can vary widely, by an order of magnitude, from 3,250 to 37,000 cfs (based on 1995–2024, Figure 55). In a drier year, like 2022, increases in May 1–14 flow would have a more substantial impact than a wetter year, like 2023 (Figure 56).

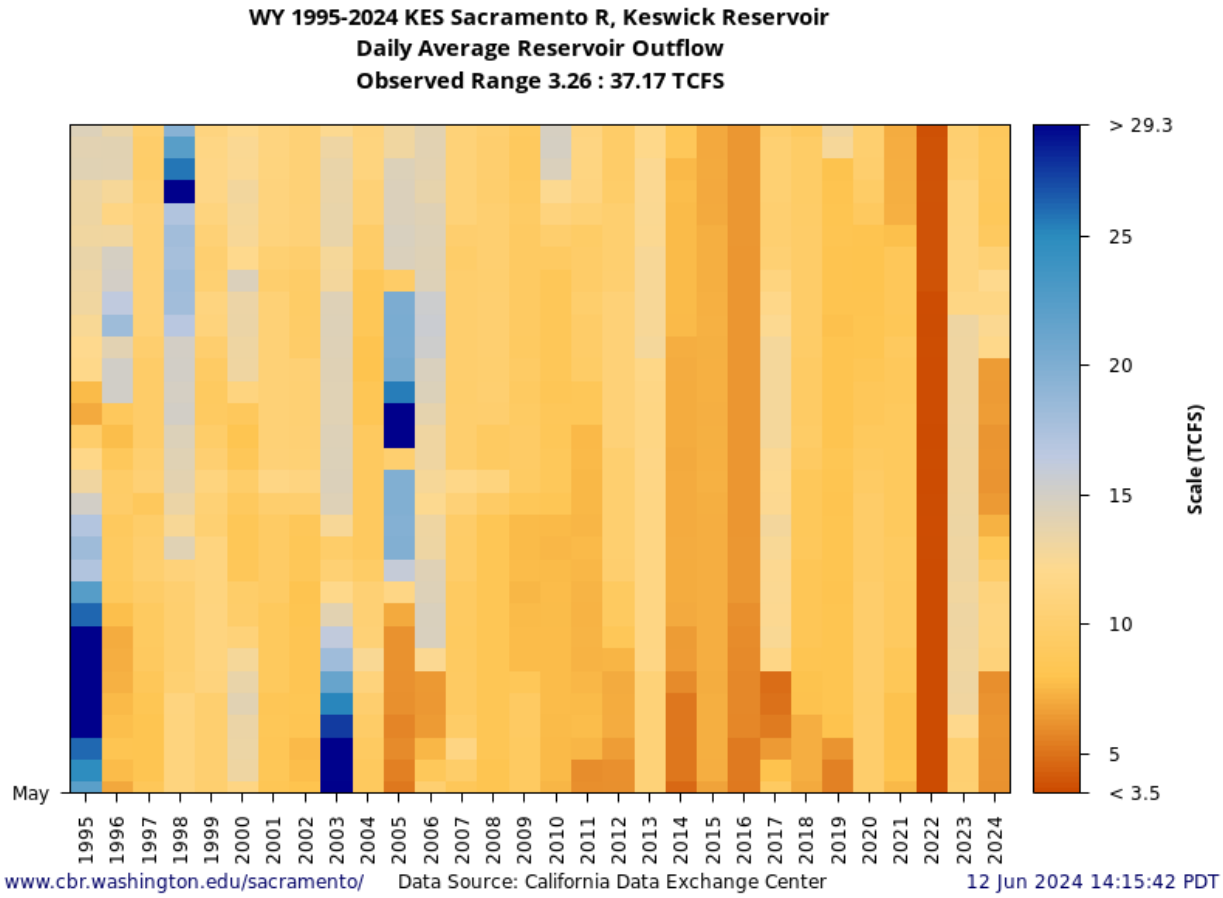


Figure 55. Keswick Reservoir daily average outflow, 1995–2024. There is a 2-week period (May 1–14) between the Bin determination (April 30) and the beginning of the temperature management season (May 15). High releases during this period could reduce the available cold water pool, especially in the drier years. Flows over the 29-year period shown are generally in the 7,000 to 8,500 cfs range during these 2 weeks (based on the most recent 10-year average, 2014–2023), but can vary widely, by an order of magnitude, from 3,250 to 37,000 cfs.

Source: (University of Washington Columbia Basin Research 2024b). SacPAS All Years River Graph. Available from www.cbr.washington.edu/sacramento/data/query_river_allyears.html

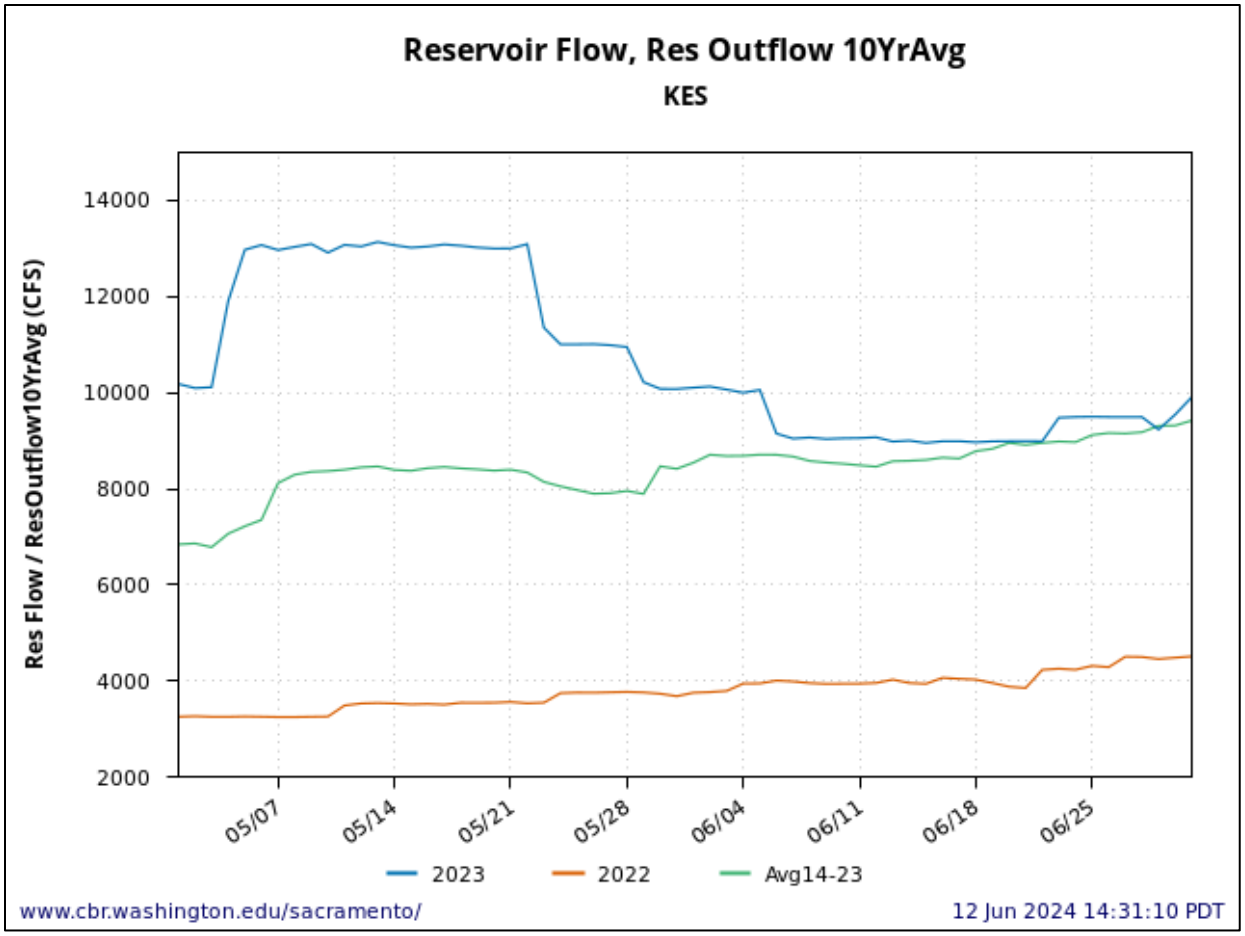


Figure 56. Keswick Reservoir daily average outflow.

Source: (University of Washington Columbia Basin Research 2024b). SacPAS River Environment Graphics & Text. Available from www.cbr.washington.edu/sacramento/data/query_river_graph.html

Additionally, NMFS notes that there is a lag time in the detection of the first SR winter-run Chinook salmon spawning, which would lead to a delay in the onset of temperature management. Aerial redd surveys are typically conducted on a weekly (or longer) basis, so redds constructed on the same day as an aerial redd survey may not be detected for a week or more. In addition, adult Chinook salmon die approximately 10 days after spawning, so when a Chinook salmon carcass is detected, redd construction likely occurred approximately 10 days earlier. Therefore, the onset of temperature management could be 7-10 days or more after the actual onset of spawning. Finally, NMFS notes that Reclamation's proposed onset of temperature management (i.e., based on real-time monitoring of redd timing) indicates that spawning at the LSNFH is not considered. There have been years where spawning at LSNFH occurred prior to the first detection of SR winter-run Chinook salmon spawning in the Sacramento River. The challenge of managing this information and response, given the limitations of monitoring, is expected to be addressed in the development of TMPs and through the SRG process.

Reclamation will collect temperature profile measurements for Shasta, Whiskeytown, and Trinity reservoirs every month and distribute through the SRG (December–February: monthly at 25-feet

intervals; March–April: every 2 weeks at 5-feet intervals; May–November 15: every week at 5-feet intervals; and November 16–30: every 2 weeks at 5-feet intervals).

As proposed, temperature management would generally conclude on October 31, but may be adjusted through coordination with the SRG and SHOT based on SR winter-run Chinook salmon spawning and emergence. NMFS notes that existing monitoring methods likely will not be able to indicate a precise date when emergence has been completed. Aerial redd surveys can only detect shallow redds, and carcass surveys monitor only a portion of the run. Only when final escapement estimates are provided in November is there an estimate of the number of females; even with that information, it is not possible to know when most of the redds were constructed, which would be required to know the date of emergence. NMFS, therefore, expects that temperature management will not extend beyond October 31. This may result in underestimating TDM, depending on November meteorological conditions.

Additionally, the winter-run JPE Subteam will complete an annual SR winter-run Chinook salmon brood year assessment by February 1 of every year. This analysis examines the health and population metrics of the cohort from the previous year and the cohort of returning adults born 3 years prior for adverse conditions, which may signal a need for intensified management actions. Indicators of adverse conditions include a previous year cohort that experienced greater than 30 percent TDM, less than 20 percent egg-to-fry survival, 25 percentile of historic JPE, TMP compliance point upstream of the CCR gauge, adverse Population Viability Trends (based on previous years annual brood year report if there was an increase in any of the five criteria in Lindley et al. [2007]), high risk of extinction (per 5-year status review), or outyear adult escapement forecast based on PFMC SR winter-run Chinook salmon stock abundance analyses. If the brood year assessment determines adverse conditions for SR winter-run Chinook salmon and identifies that Shasta storage and hydrology are expected to result in continuing adverse conditions to the coming brood year, the SHOT will report these conditions and propose actions to the Directors, and all reasonable actions will be taken to avoid continued adverse conditions. Based on the results of a brood-year assessment prepared by the winter-run JPE Subteam, representatives from Reclamation, NMFS, USFWS, and CDFW will convene to evaluate the need for protective actions (U.S. Bureau of Reclamation 2023-2024). If the assessment indicates reduced SR winter-run Chinook salmon populations, the aforementioned team will consider adjusting production levels at the LSNFH or other applicable actions outlined in the Drought Toolkit with the goal of further safeguarding the SR winter-run Chinook salmon. These indicators of brood-year strength can be revised by the SHOT, with NMFS approval.

The critical temperature threshold being used as a management target for SR winter-run Chinook salmon egg incubation is 53.5°F daily average temperature, below which there is no observed mortality due to temperature (Martin et al. 2017).

7.1.1.2.4.2. Exposure and Response to Shasta Summer Operations

7.1.1.2.4.2.1. Sacramento River Winter-Run Chinook Salmon Exposure Response

7.1.1.2.4.2.1.1. Water Temperature, Pathogens, and Disease

The SR winter-run Chinook salmon response to the Summer Cold Water Pool Management component of the proposed action is largely associated with temperature. Temperatures at or below the threshold of 53.5°F are not expected to have a biologically significant effect on

spawning adults or egg survival. At temperatures greater than the 53.5°F threshold, there would be a decrease in egg survival and potentially an increasing threat of adult pre-spawn mortality up to the 58°F threshold, beyond which point there is a high likelihood of impacts. Both of these are related to the water temperature stressor. The Summer Water Temperature and Storage, Egg Incubation and Emergence Temperature Objectives components of the proposed action are intended to coincide with SR winter-run Chinook salmon spawning and egg incubation. This is typically expected to occur in late April through October (Williams 2006), but in recent years the onset of spawning has been later in the season (National Marine Fisheries Service 2015d), so Reclamation's proposed temperature management season begins on May 15.

We reviewed Zeug et al. (2024) "Considerations for the use of laboratory-based and field-based estimates of environmental tolerance in water management decisions for an endangered salmonid," and did not find that it changed the interpretations of the NMFS egg TDM modeling that serves as the foundation of the Shasta Framework. We expect to further conversations about its application to water temperature management through the WRAP implementation.

Excessive temperatures can stress adult holding and spawning by decreasing gamete viability, shifting the initiation of spawning, slowing or blocking migration, increasing disease, and potentially interacting with other physiological stressors, such as thiamine deficiency. Although the BA says a small proportion of the population would be impacted by the sublethal effects, it is analyzed here as a large proportion since spawning is condensed to relatively few river miles.

For the purpose of discussing the impacts of the Shasta Framework and its effects on this stressor category, we start with the temperature and biological objectives of the Shasta Framework itself, because, while we do expect some exceedances of the objectives, we generally expect the following temperature-related impacts for each Bin and that they will be realized during implementation through incorporation into annual temperature management plans and reinforced through governance:

- Bin 1 years: Daily average water temperature of 53.5°F from May 15 through October 31 at or downstream of the CCR gauge, which is expected to result in a TDM of ≤3 percent. These years are expected to occur the majority of time, with the proposed action estimated approximately 80 percent of years.
- Bin 2A and B daily average water temperature of 53.5°F from May 15 through October 31 at the CCR gauge, which is expected to result in a TDM of ≤3 percent with marginal deviations that could approach 12 to 15 percent TDM. These years are expected to occur less frequently, with the proposed action estimated approximately 11.5 percent of years.
- Bin 3 years: A daily average water temperature of 53.5°F from May 15 through October 31, upstream from the CCR gauge, which is expected to result in a TDM of ≤30 percent with higher exceedances possible. The modeling shows that some years could have extremely high levels of TDM, but NMFS expects the deviation will be minimized through real-time operations so that it is limited to up to a 10-percent increase from the objective. These years are expected to occur in approximately 8.5 percent of years.

Modeling that was used to develop the Shasta Framework illustrated that in some years the objectives cannot be met, most notably Bin 2 and Bin 3 years, where we expect there could be a deviation of up to 10 percent from the objective (i.e., in Bin 2 years, the TDM could be up to 13 percent if approved by the SRG and the SHOT). However, we believe the collaborative and consensus-driven process of governance will reinforce the objectives and will ensure that any

deviations reasonably consider all of the actions that could have otherwise been taken to maintain the objectives. Additionally, Reclamation is committed to the objectives as described in the proposed action; therefore, we conclude that they are reasonably certain to occur and rely on them to inform the effects of the proposed action on SR winter-run Chinook salmon.

The proposed action is designed to respond to variable population sizes and to take action when population trends are determined to be adverse based on an annual brood year assessment. For the Shasta Reservoir, we expect that the majority of years will be managed to enhance and maintain populations through dynamic approaches to water temperature management. When conditions are limited, they will be managed to protect the species through adjusted temperature management strategies.

Survival in the upper river is high, however there are certain years where survival is compromised. The Shasta Framework is carefully crafted to respond to these conditions with several approaches, including Bin-specific operational and biological objectives and use of the LSNFH Recovery Supplementation Program when conditions are expected to negatively affect in-river survival. The WRAP has priorities that are expected to improve the abundance of SR winter-run Chinook salmon over the next 10 years.

We expect the proposed action to improve the abundance of SR winter-run Chinook salmon over baseline conditions to the extent that improved temperature management objectives reduce TDM.

Water temperatures in the summer in the Sacramento River can also impact adult spawning and juvenile rearing and is analyzed here based on the percent of months outside the optimal 42.1°F to 55°F water temperature range for successful spawning and holding of SR winter-run Chinook salmon for the Sacramento River at Keswick Dam and the CCR gage, from January through July (Tables 7 and 8 in U.S. Bureau of Reclamation 2023-2024). At Keswick Dam, 2 percent of the months would be outside this range under the proposed action, compared to 6 percent under the NAA and 4 percent under EXP3. At the CCR gauge, 10 percent of the months would be outside this range under the proposed action, compared to 19 percent under the NAA and 16 percent under EXP3. At both locations, under the proposed action, there is not a wide range in outcomes across water types, ranging from 0 to 5 percent upstream at Keswick Dam, and 5 to 14 percent at the CCR gauge, with conditions generally worse under drier conditions. Similarly, pathogens and disease for adults were analyzed at the same locations based on the percent of months above the 59.9°F pathogen virulence water temperature threshold for adult SR winter-run Chinook salmon spawning and holding from January through July, however, there were no monthly exceedances of this metric anticipated for the proposed action, NAA, and EXP3 (all of which were 0 percent across all water year types, Tables 9 and 10 in U.S. Bureau of Reclamation 2023-2024). However, daily temperatures in excess of 60°F were experienced in recent droughts (e.g., 2021) during adult holding and spawning, indicating the potential for impacts under existing conditions.

7.1.1.2.4.2.1.2. Stranding and Dewatering

Similar to the effects noted due to Fall Operations, in the late summer months, especially August (Figure 57), as flows drop, trapped juveniles can die from desiccation, high temperatures, low dissolved oxygen, or higher levels of predation in habitat disconnected from the main channel after reductions in reservoir releases.

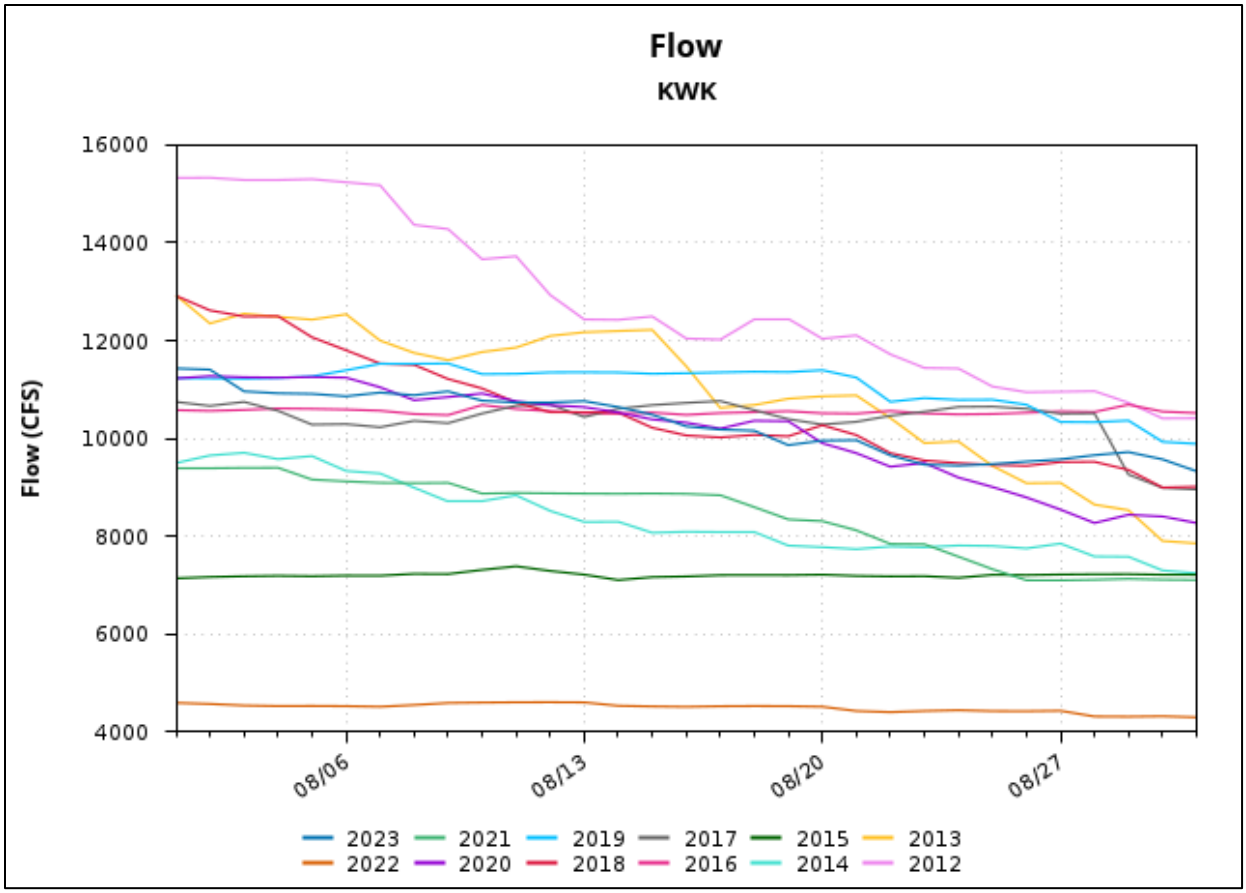


Figure 57. August flows (in cubic feet per second) at Keswick (KWK) gauge from 2012 to 2023.

Source: (University of Washington Columbia Basin Research 2024b). SacPAS River Environment Graphics & Text. Available from www.cbr.washington.edu/sacramento/data/query_river_graph.html

Stranding on the Sacramento River in August through November is primarily a result of the artificially high river flows from summer reservoir releases (Brown and Bauer 2010, Zimmerman et al. 2018), followed by drops in flows to rebuild storage. Prior to Shasta Dam construction about 80 years ago, Central Valley Chinook salmon, which likely evolved at least 11,000 years ago (Waples et al. 2008), would have experienced a very different summer hydrograph. Unimpaired flow modeling provides an estimate of the water flow if it had not been stored in reservoirs, imported, exported, or diverted, and indicates that summer flows in the Sacramento are very inflated (California Environmental Flows Working Group 2021, Zimmerman et al. 2023). For example, median unimpaired dry-season baseflow at Bend Bridge would have been about 1,300 cfs, but the observed flow is about five times as much, 6,600 cfs. As shown in Figure 57, the effects of this stressor under existing conditions can be substantial, with 5,000 cfs reductions at KWK, even in a single month, such as August of 2012 and 2013, or 2,000 cfs reductions, most recently in August 2023.

The modeled impact of the proposed action indicates an average stranding risk of approximately 8,000 fish across all water types (ranging from about 6,000 fish in wet years to 11,000 fish in critical years). The impact is minimized through the implementation of ramping rates and is the

ultimate consequence to individuals from ramping flows down from summer peaks through the fall. The effect was previously discussed under Fall and Winter Operations but mentioned here since the impact begins during the summer when flows begin to drop from their highest managed releases. For context, the fry equivalents of juvenile production at Red Bluff Diversion Dam (also known as the Juvenile Production Index for Fry) was 311,058 fry in 2022, meaning that the 10,837 fry stranded under modeled proposed action operations in a hypothetical critical year would constitute about 3.4 percent of the Juvenile Production Index based on monitoring from the most recent actual critical year (National Marine Fisheries Service 2023c). Conversely, the following year, under very wet conditions, there were about five times as many fry equivalents estimated at RBDD, reducing the relative impact of juvenile stranding (LTO Appendix – Winter-Run Juvenile Production Estimate in U.S. Bureau of Reclamation 2023-2024). The severity of the stressor is lethal (stranded juvenile CCV steelhead face immediate risk of death from desiccation, suffocation and heat stress, and even survivors can experience stunted growth or increased vulnerability to predators due to the physiological stress of being trapped), the proportion of the population exposed is small (before the end of October about half of the year's cohort of juveniles will have migrated past Red Bluff Diversion Dam), the frequency of exposure is high (annual), the magnitude of effect is medium, and the weight of evidence is high.

Relative to the NAA, the proposed action is estimated to reduce stranding marginally, specifically a 3-percent decrease in stranding across all water year types (from 8,481 fry under the NAA to 8,224 fry under the proposed action Alt2v1 (Appendix L Attachment L Table X-4 in U.S. Bureau of Reclamation 2023-2024). Relative to EXP3, the proposed action is estimated to reduce stranding by about one-quarter, specifically a 25-percent decrease in stranding across all water year types (from 10,934 fry under EXP3 to 8,224 fry under the proposed action Alt2v1, Appendix L Attachment L Table X-4 in U.S. Bureau of Reclamation 2023-2024).

Redd dewatering occurs when water levels drop below the depth of an existing redd. Consistent with past operations under the SRTTG, redd dewatering is defined here for salmon and steelhead analysis as when the redd cap is exposed to air. The expected percentage of redds dewatered for SR winter-run Chinook salmon egg incubation in the Sacramento River from Keswick Dam to the Battle Creek confluence is 13 percent under the proposed action, 14 percent under the NAA, and 9 percent under EXP3. The proposed action is anticipated to result in a higher risk of redd dewatering in drier years (up to 15 percent in critical water years) and less so in wetter years (as little as 7 percent in wet years, Appendix L Attachment L Table X-11 in U.S. Bureau of Reclamation 2023-2024). The severity of the stressor is lethal (dewatering of redds suffocates the eggs by cutting off their oxygen supply), the proportion of the population exposed is small (since most eggs have emerged from their redds before the end of October), the frequency of exposure is high (annual), the magnitude of effect is medium, and the weight of evidence is high.

Historically, dewatering has affected less than 2 percent of SR winter-run Chinook salmon redds and this is the dewatering rate that we expect to continue as a result of the proposed action.

7.1.1.2.4.2.1.3. Refuge Habitat and Food Availability and Quality

Refuge Habitat, Food Availability and Quality are generally at their highest overall levels during summer operations because, aside from winter spills, managed summer flows are higher than other seasonal operations periods and, therefore, tend to inundate more available habitats and connect more habitats that may stimulate biomass and food production.

The expected WUA for SR winter-run Chinook salmon fry rearing in the Sacramento River from Keswick Dam to the Battle Creek confluence, averaged across all years, is 247,705 under the proposed action, which is nearly indistinguishable 247,838 under the NAA, but somewhat less than the 265,748 anticipated under EXP3. The range under the proposed action is associated with water year type, from a minimum of 234,984 in wet years to a maximum of 259,957 in critical years. Even stratified by water years, there is little difference (less than 1 percent) between the proposed action and NAA. Relative to EXP3, there is a predicted 1 to 12-percent decrease (depending on water year type, with the greatest decrease in wetter years, and the smaller decrease in drier years) in rearing habitat for SR winter-run Chinook salmon juvenile rearing in the Sacramento River from Keswick Dam to the Battle Creek confluence, with an average 7-percent decrease across all water year types (Appendix O Attachment XX Table X-7 in U.S. Bureau of Reclamation 2023-2024). The change could be attributed to water temperature management, which is part of the proposed action and shapes discretionary releases through the summer. For refuge habitat, the severity of the stressor is sublethal (without adequate refuge habitat, juveniles would be more susceptible to predators, leading to increased stress and potentially higher mortality rates. Additionally, insufficient food availability or poor-quality food could result in reduced growth rates, delayed maturity, and decreased overall fitness. These sublethal effects could then translate into lower reproductive success and reduced population numbers over time.), the proportion of the population exposed is large (since the single population of SR winter-run Chinook salmon rear in the Sacramento River watershed), the frequency of exposure is medium (with the decrease in rearing habitat contingent on water year type), the magnitude of effect is medium, and the weight of evidence is medium (while we have a good understanding of SR winter-run Chinook salmon populations due to monitoring, the conclusions are based on a modeling approach that has inherent limitations and is best interpreted in a relative context).

7.1.1.2.4.2.1.4. Spawning Habitat

Spawning habitat is affected by flows and water temperatures. The Bin system will seek to increase the amount of suitable spawning habitat in Bin 1 years by managing water temperatures at or below the CCR gauge at 53.5°F from May 15 through October 31. In Bin 2 years, this habitat will be managed at the CCR gauge. In Bin 3 years, the habitat will be managed upstream from the CCR gauge as agreed to by the SHOT. This dynamic approach is in response to dramatic changes in California hydrology that can swing from wet to dry for short or extended periods. The result is that the amount and extent of suitable habitat during dry years could be several miles less than the amount that is available during wet years. In all cases, the spawning habitat will be managed to meet the same seasonal temperature objective of 53.5°F from May 15 through October 31.

The expected WUA for SR winter-run Chinook salmon spawning in the Sacramento River from Keswick Dam to the Battle Creek Confluence is 551,576 under the proposed action, 545,832 under the NAA, and 592,655 under EXP3. Relative to NAA, the proposed action will result in a 1-percent increase in WUA, when averaged across all years. Relative to EXP3 there is an expected 7-percent decrease in spawning habitat for SR winter-run Chinook salmon (Table X-5 in U.S. Bureau of Reclamation 2023-2024). There is not a clear pattern between the WUA and watershed inflow (as measured by water year type), with the highest WUA in the proposed action in critical and dry years, followed by wet years, then below normal and above normal. The overall weight of evidence regarding its impact is limited by the WUA modeling approach

employed (Railsback 2016). Specifically, the modeling uses monthly averages, potentially missing short-term fluctuations, neglects rearing habitat downstream of Battle Creek, does not account for all factors influencing habitat suitability, assumes channel characteristics remain stable over time, and fundamentally produces a unitless index, not a direct measure of area used for spawning. Regardless, based on the information available, the severity of the stressor is lethal (without adequate spawning habitat, adults cannot establish viable redds, leading to egg loss and reduced offspring survival), the proportion of the population exposed is high (since the single population of SR winter-run Chinook salmon rear in the Sacramento River watershed), the frequency of exposure is high (with impacts across all water year types), the magnitude of effect is high, and the weight of evidence is medium (while we have a good understanding of SR winter-run Chinook salmon populations due to monitoring, the conclusions are based on a modeling approach that has inherent limitations and is best interpreted in a relative context).

7.1.1.2.4.2.1.5. Redd Quality

Increased flows improve dissolved oxygen and reduce sedimentation in redds, improving egg and alevin development. These effects are not directly modeled in the proposed action, but increased Shasta reservoir storage under the framework will allow increased river flows during eggs incubation to fry emergence, thereby improving redd quality. The severity of the stressor is sub-lethal (increasing metabolic stress on incubating eggs), the proportion of the population exposed is large (since the single population of SR winter-run Chinook salmon rear in the Sacramento River watershed), the frequency of exposure is high (Shasta and Keswick dams alter natural river flows in most months and years), the magnitude of effect is high, and the weight of evidence is medium (redd quality was not directly modeled, but redds of SR winter-run Chinook salmon on the Sacramento River are well monitored).

Summer operations is the period where Redd Quality is most directly influenced by Reclamation and similar to spawning habitat, it is driven by the Bin system of the Shasta Framework. In Bin 1 years, redd quality will be managed with water temperatures of 53.5 at or below the CCR gauge from May through October 31. In Bin 2 years, water temperatures of 53.5 will be managed at the CCR gauge from May through October 31, and in Bin 3 years, water temperatures of 53.5 will be managed at some location upstream of the CCR gauge from May through October 31.

7.1.1.2.4.2.2. Central Valley Spring-Run Chinook Salmon Exposure and Response

7.1.1.2.4.2.2.1. Water Temperature, Pathogens, and Disease

Central Valley spring-run Chinook salmon, once abundant throughout the Sacramento River basin, now face a reduced range with holding and spawning on the mainstem Sacramento River limited to downstream of Keswick Dam. As with SR winter-run Chinook salmon, CV spring-run Chinook salmon response to the Summer Operations component of the proposed action is primarily associated with temperature. Temperatures above the 61°F 7-day average of the daily maximum temperatures (7DADM) threshold for adult Chinook salmon holding can affect the timing of key processes such as spawning or can lead to stress, disease, bioenergetic depletion, or death. Exposure to high temperatures just prior to spawning can affect gametes held internally in adults, resulting in a loss of viability that appears as poor fertilization or embryo survival (EPA 2003). Temperatures above the 53.5°F threshold would cause decreased egg survival.

The start of the Water Temperature and Storage, Egg Incubation and Emergence Temperature Objectives component of the proposed action corresponds to the very first few CV spring-run

Chinook salmon adults passing Red Bluff Diversion Dam during their upstream migration. In dry years, about 10 percent of returning CV spring-run Chinook salmon adults will have passed upstream of the Red Bluff Diversion Dam by May 15, while in wet years less than 5 percent will have passed (Vogel and Marine 1991). Adult migration into the Sacramento River tributaries of Battle, Clear, Mill, Deer, and Butte creeks typically ends mid-July or August (Lindley et al. 2004). Once CV spring-run Chinook salmon reach the upper reaches of the river, adults will hold prior to spawning, a period that continues until September. Central Valley spring-run Chinook salmon spawning occurs August–October (Yoshiyama et al. 1998), with CDFW aerial redd surveys from 2003 to 2014 indicating that about 84 percent of redds are constructed upstream of Balls Ferry. Given the timing and distribution of redds, a large proportion of the CV spring-run Chinook salmon redds and eggs would be exposed to the conditions associated with Summer Operations.

Excessive temperatures can stress adults holding and spawning by decreasing gamete viability, shifting the initiation of spawning, slowing or blocking migration, increasing disease, and potentially interacting with other physiological stressors, such as thiamine deficiency.

The BA reports that under the proposed action, water temperatures in the Sacramento River for about 7 percent of months (at Keswick Dam) and 96 percent of months (at Red Bluff Diversion Dam), from April through October averaged across all years, will be outside the 42.1°F to 55°F water temperature range for minimal adult CV spring-run Chinook salmon migration impairment (Tables 8 and 9 of Chapter 6 in U.S. Bureau of Reclamation 2023-2024).

Under the proposed action at Keswick Dam, the stressor is minimal during wet and above normal years (0 percent) and modest during below normal and dry years (3 to 5 percent), but high during critical years (30 percent). Whereas at Red Bluff Diversion Dam under the proposed action, the stressor has a high impact in all year types (from 89 percent of months in wet years to 100 percent of months in critical years). These impacts, however, are fairly similar to under the NAA (9 percent at Keswick and 96 percent at Red Bluff Diversion Dam). The stressors are anticipated to be lethal (Elevated water temperatures can increase the susceptibility of CV spring-run Chinook salmon to pathogens and diseases, leading to higher mortality rates. Warmer water temperatures can also promote the growth and virulence of pathogens.), the proportion of the population exposed is large (since the Sacramento River is a central migratory corridor for CV spring-run Chinook salmon), the frequency of exposure is high(with effects in all year types at Red Bluff Diversion Dam), the magnitude of effect is high, and the weight of evidence is high (since this reach of the Sacramento River has temperature gauges and fish monitoring to determine their exposure to this stressor).

The percent of months from April through December outside the optimal 55.4°F to 68°F water temperature range for successful yearling rearing of CV spring-run Chinook salmon under the proposed action is 94 percent at Keswick Dam and 27 percent at Red Bluff Diversion Dam (Tables 20 and 21 in U.S. Bureau of Reclamation 2023-2024). This is similar to what is anticipated under the NAA (94 percent at Keswick Dam and 26 percent at Red Bluff Diversion Dam) and EXP3 (95 percent at Keswick Dam and 23 percent at Red Bluff Diversion Dam). The severity of the stressor is lethal (Elevated water temperatures can increase the susceptibility of CV spring-run Chinook salmon to pathogens and diseases, leading to higher mortality rates. Warmer water temperatures can also promote the growth and virulence of pathogens.), the proportion of the population exposed is small (anticipating that yearlings would primarily use tributary habitat rather than the mainstem), the frequency of exposure is high (with effects in all

year at Keswick Dam), the magnitude of effect is medium, and the weight of evidence is medium (since this reach of the Sacramento River has temperature gauges and fish monitoring to determine their exposure to this stressor).

As previously mentioned in the analysis of CV spring-run Chinook salmon exposure and response to Shasta Spring Operations (Section 7.1.1.2.3.3.2), Chinook salmon populations are susceptible to a variety of pathogens found in aquatic environments including bacteria, protozoa, viruses, and parasites, in spawning grounds, rearing habitats, hatcheries, migratory corridors, and the marine environment. Under the proposed action, during critical years, the percent of months from April through October above the 59.9°F pathogen virulence water temperature threshold for the adult CV spring-run Chinook salmon migration is 17 percent, compared to 15 percent under the NAA and 5 percent under EXP3 (Table 11 of Section 6.2.2.3 in U.S. Bureau of Reclamation 2023-2024). The severity of the stressor is lethal (Elevated water temperatures can increase the susceptibility of CV spring-run Chinook salmon to pathogens and diseases, leading to higher mortality rates. Warmer water temperatures can also promote the growth and virulence of pathogens.), the proportion of the population exposed is large (since the Sacramento River is a central migratory corridor for CV spring-run Chinook salmon), the frequency of exposure is low (limited to critical years), the magnitude of effect is high, and the weight of evidence is medium (disease is a well-documented stress on adults, including mortality events in recent drought years, but field data for this population is limited).

7.1.1.2.4.2.2.2. Spawning Habitat, Stranding, and Dewatering

Summer operations have the potential to result in redd dewatering for early spawning adults in August. This is also a risk of stranding rearing yearlings during the summer as high flows begin to recede in August. Central Valley spring-run Chinook salmon stranding data is sparse. For example, during the 2022–2023 season, sampling estimated there were three CV spring-run Chinook salmon in Upper Sacramento River stranding pools, and 108 fall-run Chinook salmon (Chelberg 2023). However, fall-run Chinook salmon may be a useful indicator of stranding trends. Between 2012 and 2021, an average of 4,492 fall-run Chinook salmon were observed stranded annually (U.S. Bureau of Reclamation 2023).

The estimated percent of redd dewatering potential for CV spring-run Chinook salmon egg incubation in the Sacramento River from Keswick Dam to the Battle Creek Confluence is 18 percent under the proposed action, 18 percent under the NAA, and 10 percent relative to EXP3 (Appendix L Attachment L Table X-13 in U.S. Bureau of Reclamation 2023-2024). The dewatering potential under the proposed action generally increases in wetter years so that it ranges from 8 percent in critical years, to 13 percent in dry and below normal years, to 25 percent in wet years, and 29 percent in above normal years. The severity of the stressor is lethal (factors like stranding [isolation in drying pools] and dewatering [loss of water flow] can directly kill juveniles and developing eggs by cutting them off from necessary oxygen and water), the proportion of the population exposed is small (since a larger proportion of rearing occurs on tributaries), the frequency of exposure is high (with impacts in most water years), the magnitude of effect is high, and the weight of evidence is high (stranding and dewatering are well-documented stressors, although field data for this population is limited due to the rarity of spawning in the mainstem Sacramento River).

Yearling rearing and migration are also expected to experience impacts to stranding due to the proposed storage and release of water, although it will be variable across water year types. Based

on modeling of potential juvenile stranding for CV spring-run Chinook salmon fry rearing in the Sacramento River from Keswick Dam to the Battle Creek confluence, the proposed action, on average, will result in 7,916 juveniles potentially stranded. Relative to the NAA, the proposed action will have similar amounts of stranding averaged across all water year types, although this is a result of decreased stranding in wet and above normal years but increased stranding in below normal, dry and critical years. Similarly, relative to EXP3, the proposed action is expected to reduce stranding by 6 to 17 percent in relatively wetter (wet and above normal) years. However, it is expected to increase stranding by 5 to 16 percent in drier (below normal, dry and critical) years (Table 19). The severity of the stressor is lethal (stranded fish may be killed by predators or desiccation), the proportion of the population exposed is medium, the frequency of exposure is medium, the magnitude of effect is high, and the weight of evidence is high.

With relation to the stressors of spawning habitat, NMFS considers that the managed changes in the hydrograph can reduce access to riparian habitat and instream cover both in the immediate area of releases and further downstream (e.g., less frequent inundation of side channels). These changes can reduce accessibility to habitat that may support successful out-migration survival by providing rearing areas, refuge, or increased food availability. Under the proposed action, the expected WUA for spring-run Chinook salmon spawning in the Sacramento River from Keswick Dam to the Battle Creek Confluence ranges from about 343,000 in wet years to about 448,000 in critical years, with an average of about 400,000 across all years modeled. There is minimal change (<1 percent averaged across all water years) in spawning habitat as measured by weighted usable area, relative to NAA, but a 12-percent decrease relative to EXP3 (Appendix O, Attachment XX, Table X-17 in U.S. Bureau of Reclamation 2023-2024). However, the magnitude of the effect is low, because of low exposure, with only a remnant spawning population of CV spring-run Chinook salmon in the Sacramento River. Therefore, in summary, the severity of the stressor is sub-lethal (lack of spawning habitat reduces the number of suitable places for adults to lay their eggs, leading to fewer offspring, even without directly killing adult fish), the proportion of the population exposed is small (since they primarily spawn in smaller tributaries rather than the mainstem Sacramento River), the frequency of exposure is medium (with effects across all water years, but a low variability due to the proposed action), the magnitude of effect is low, and the weight of evidence is medium (informed by the relative impacts of the model runs).

7.1.1.2.4.2.2.3. Refuge Habitat and Food Availability and Quality

With relation to the stressors of refuge habitat and food availability and quality, NMFS considers that the managed changes in the hydrograph can impact access to riparian and floodplain habitat and instream cover in the immediate area of releases, but perhaps more so further downstream and during Winter and Spring operations (e.g., less frequent overtopping of Fremont Weir and access to Yolo Bypass habitat). In the vicinity of the Sacramento River below Keswick Dam, refuge habitat, food availability and quality are generally at their highest overall levels during summer operations because, aside from winter spills, managed summer flows are higher than other seasonal operations periods and therefore tend to inundate more available habitats and connect more habitats that may stimulate biomass and food production. However, reviews of scientific literature on flow alteration have shown that fish abundance, diversity, and demographic rates consistently decline in response to both elevated and reduced flow magnitude (Poff and Zimmerman 2010). Substantially higher summer flows under the proposed action further impair the hydrograph and can thereby disrupt the aquatic food web, leading to a scarcity

of essential prey resources, benefiting invasive competitors, and potentially favoring less nutritious prey species. For example, comparisons of the Sacramento River and Yolo Bypass indicted that chlorophyll a levels and densities of Diptera were significantly higher in the floodplain than in the river, while copepods and cladoceran densities were similar in the river and its floodplain—with chlorophyll a, copepods, and cladoceran densities negatively associated with flow (Sommer et al. 2004). Therefore, on balance, these inflated summertime flows may shift the location of optimal foraging areas for CV spring-run Chinook salmon juveniles to different areas than they may have otherwise utilized, depending on the adequacy of water quality and productivity of the food web (Jeffres et al. 2020). The severity of the stressor is sublethal (lack of refuge habitat forces juvenile salmon into the open, increasing their vulnerability to predators and reducing their ability to conserve energy, leading to slower growth and potentially lower survival rates. Poor food availability and quality can also cause nutritional deficiencies, weakening the salmon and making them more susceptible to disease and stress.), the proportion of the population exposed is large since a large proportion of CV spring-run Chinook salmon juveniles utilize portions of the Sacramento River, the frequency of exposure is high since these elevated summertime flows occur in most years, the magnitude of effect is high, and the weight of evidence is medium since the net impact is difficult to quantify but the underlying food web dynamics are well documented.

7.1.1.2.4.2.3. California Central Valley Steelhead Exposure and Response

7.1.1.2.4.2.3.1. Water Temperature

By the start of Summer Cold Water Pool Management, juvenile CCV steelhead will have started their migration out of the Upper Sacramento River and tributaries with about 10 percent of juveniles having already passed Red Bluff Diversion Dam by May 15 (University of Washington Columbia Basin Research 2019). The remaining 90 percent of juvenile CCV steelhead still in the Upper Sacramento River would experience the conditions upstream of Red Bluff Diversion Dam associated with the early temperature management season. By July, some adult CCV steelhead will have passed upstream of the Red Bluff Diversion Dam with peak migration in September and October (McEwan 2001). There is limited information regarding CCV steelhead spawning locations in the Sacramento River, but since CCV steelhead spawning and eggs/alevin incubation occurs from November through April, effects to eggs are not considered under the effects of Summer Operations.

7.1.1.2.4.2.3.2. Stranding Risk

Modeling anticipates variable impacts of the proposed action on juvenile CCV steelhead stranding in the Sacramento River from Keswick Dam to Battle Creek, depending on the water year type ranging from a low of 3,544 individuals in dry years to 7,973 in wet years and averaging 5,107 individuals across all water year types (see Appendix L, Attachment L, Table X-8 in U.S. Bureau of Reclamation 2023-2024). The severity of the stressor is lethal (since stranded juveniles can die from desiccation, high temperatures, low dissolved oxygen, or higher levels of predation in habitat disconnected from the main channel after flow reductions), the proportion of the population exposed is medium (the upstream reach of the Sacramento River especially impacted by Shasta Dam operations serves as rearing habitat for a proportion of CCV steelhead yearlings and young of year), the frequency of exposure is high (with effects in all water years), the magnitude of effect is high, and the weight of evidence is high.

7.1.1.2.4.2.3.3. Pathogens and Disease

Lower water temperatures are associated with a reduction in the prevalence of pathogens and diseases, potentially improving the fitness and migration success of adult CCV steelhead. Salmonid pathogens and diseases can spread vertically (parent to offspring) or horizontally (between individuals) as described by Baxa-Antonio et al. (1992). Seasonal water management practices that reduce river flow can concentrate pathogens, facilitating horizontal transmission and rising water temperatures can increase the virulence of pathogens. McCullough (1999) indicated that diseases affecting salmonids become highly virulent at temperatures exceeding 59.9°F (U.S. Bureau of Reclamation 2023-2024).

Table 26 shows that in most years, pathogen virulence immediately below Keswick Dam, where Reclamation's discretionary influence is highest, is absent but in critical years, the threshold of 59.9°F is exceeded in 13.5 percent of months. Moving further downstream, virulence increases as water temperatures warm. At Red Bluff Diversion Dam and Hamilton City, where Reclamation's discretionary influence of virulence is low, warming water temperatures increase the frequency of months and water year types where thresholds are exceeded.

For adult CCV steelhead migration, the proposed action may result in an exceedance of the pathogen virulence threshold of 59.9°F from July through March near Keswick Dam in 13.5 percent of months in critical years (with highest temperatures in September and October of those years) but does not exceed the threshold in any monthly averages for other water year types at that location (Table 10 in U.S. Bureau of Reclamation 2023-2024). Further downstream near Red Bluff Diversion Dam, the threshold is exceeded in 35 percent of months for critical years (Table 12 in U.S. Bureau of Reclamation 2023-2024) and downstream from there it is exceeded in 44 percent of months at Hamilton City (Table 11 in U.S. Bureau of Reclamation 2023-2024). Moving further downstream from Keswick Dam, the exceedances increase while the influence of Shasta water operations on temperatures decreases (Daniels and Danner 2020) so that averaged across all years the percentage of months above the threshold increases from 2 percent at Keswick Dam, to 8 percent at Red Bluff Diversion Dam to 35 percent at Hamilton City. Note that while there are relative improvements downstream, the magnitude of the stressor is higher—exceeding the pathogen virulence threshold more than 35 percent of months (July–March) across all water year types, with even higher frequency in dry and critical years (Table 26). It is understood that the effects of cold water releases from Shasta attenuate moving downstream (Daniels and Danner 2020), so during the temperature management season, Keswick Dam (river mile 302) is usually cooler than Red Bluff Diversion Dam (river mile 243), and Hamilton City (river mile 205). The downstream reaches are warmer, and less able to be managed via Shasta Reservoir cold water pool.

Table 26. Percent of months above the 59.9°F pathogen virulence water temperature threshold for adult California Central Valley steelhead migration by water year type and for all years combined, Sacramento River at Keswick Dam, July through March.

Water Year Type	Proposed Action	EXP3	NAA
Keswick Dam			
Wet	0.0	0.0	0.0

Water Year Type	Proposed Action	EXP3	NAA
Above Normal	0.0	0.0	0.0
Below Normal	0.0	0.0	0.0
Dry	0.0	0.0	0.0
Critical	13.5	4.3	12.1
All	2.1	0.7	1.9
Red Bluff Diversion Dam			
Wet	2.0	17.9	2.8
Above Normal	0.0	10.9	0.0
Below Normal	4.3	12.3	8.6
Dry	5.1	8.3	8.3
Critical	34.8	31.2	35.5
All	8.1	15.7	10.0
Hamilton City			
Wet	29.4	37.3	29.8
Above Normal	27.7	38.7	27.7
Below Normal	35.8	40.1	35.2
Dry	39.4	39.4	38.4
Critical	44.0	43.3	44.0
All	35.1	39.4	34.8

Source: Tables 10-12 in (U.S. Bureau of Reclamation 2023-2024)

The percent of months above the 59.9°F pathogen virulence water temperature threshold for juvenile CCV steelhead rearing and out-migration at Keswick Dam is about 2 percent under the proposed action, 1 percent under the NAA, and less than 1 percent under EXP3. The impacts are greater at Red Bluff Diversion Dam, about 14 percent under the proposed action, 18 percent under the NAA, and 26 percent under EXP3 (Tables 59 and 60 in U.S. Bureau of Reclamation 2023-2024). The severity of the stressor is sub-lethal (summer/fall), the proportion of the population exposed is medium, the frequency of exposure and weight of evidence are medium, and as a result, the overall magnitude of the effect is medium. Additionally, for kelts, the percent of months from February through June above the 59.9°F pathogen virulence water temperature threshold for emigration, averaged across all water years, was about 18 percent under the proposed action, 26 percent under the NAA, and 34 percent under EXP3 (Table 36 in U.S. Bureau of Reclamation 2023-2024). The improvement is substantial under the proposed action, 30 percent better than the NAA and 47 percent better than EXP3 when averaged across all water

years. However, the BA (U.S. Bureau of Reclamation 2023-2024) notes the uncertainty regarding this life stage, "Presence of pathogens and disease may increase stress on steelhead kelts, reducing fitness and impairing emigration. It is uncertain how pathogens and disease may influence rates of anadromy and out-migration cues." The severity of the stressor is lethal (elevated water temperatures can increase pathogen virulence in juvenile CCV steelhead, making them more susceptible to disease and mortality), the proportion of the population exposed is medium (the upstream reach of the Sacramento River especially impacted by Shasta Dam operations serves as rearing habitat for a proportion of CCV steelhead yearlings and young of year), the frequency of exposure is high (with measurable effects in most water years), the magnitude of effect is high, and the weight of evidence is high (supported by robust temperature and fish monitoring data on to quantify the exposure).

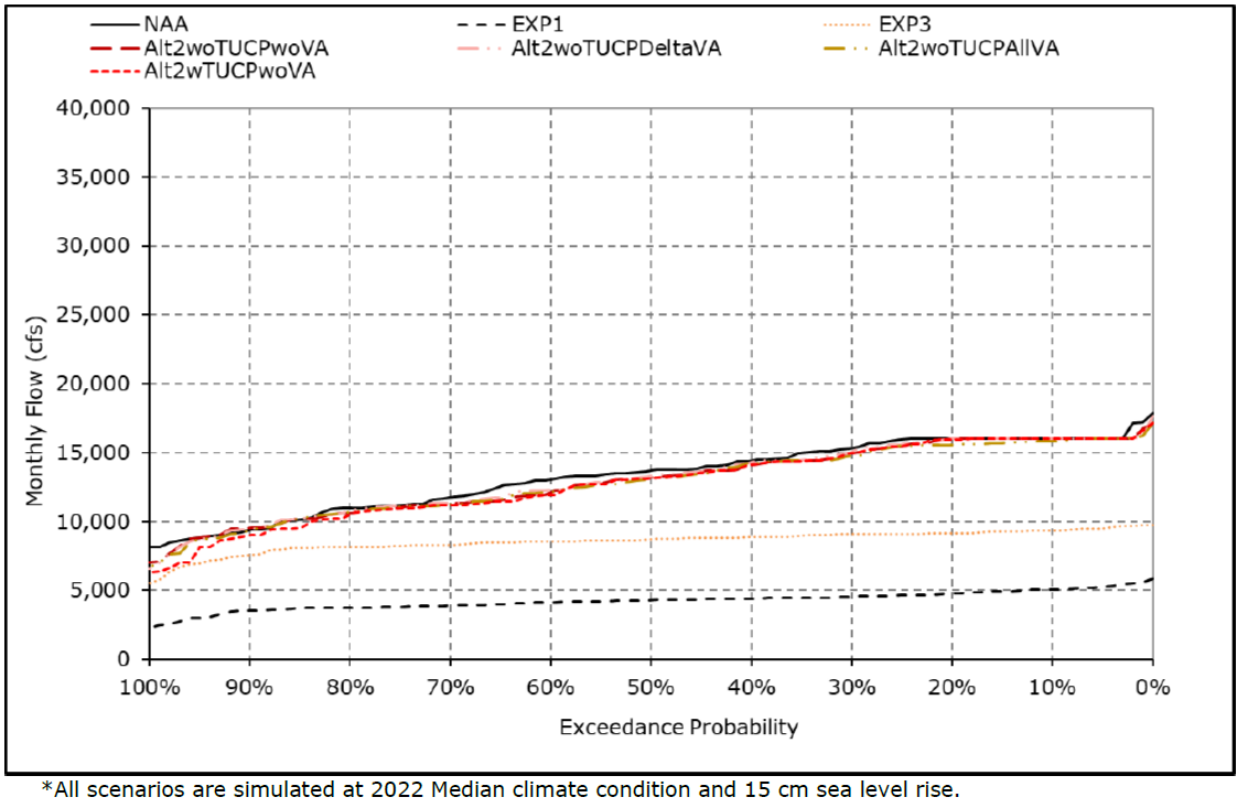
7.1.1.2.4.2.3.4. Refuge Habitat and Food Availability and Quality

Refuge Habitat, Food Availability and Quality are generally at their highest overall levels during summer operations because, aside from winter spills, managed summer flows are higher than other seasonal operations periods and therefore tend to inundate more available habitats and connect more habitats that may stimulate biomass and food production.

Sacramento River natal and mainstem young-of-year rearing are present during Shasta Division summer operations (Figure 16 in U.S. Bureau of Reclamation 2023-2024). There is little difference in long-term average summer flows at Keswick Dam between the proposed action and the NAA, but relative to EXP3, the proposed action is expected to increase long-term average flows in the Sacramento River from June through September at Keswick Dam (Figure F.2.2-3-1), Bend Bridge (Figure F.2.2-4-1), Red Bluff Diversion Dam (Figure F.2.2-5-1), Hamilton City (Figure F.2.2-6-1), Wilkins Slough (Figure F.2.2-7-1), Freeport (Figure F.2.2-14-1) and Rio Vista (Figure F.2.2-15-1, figure references from Appendix F: Modeling Section 1-1 in U.S. Bureau of Reclamation 2023-2024). Moving downstream, flows are increasingly influenced by other infrastructure and operations as well as unregulated accretions and depletions, but in net, the long-term average summer flow increases under the proposed action extend most of the 300 or so miles of the Sacramento River (from Keswick Dam to the confluence of the San Joaquin River). Young-of-year CCV steelhead will experience these increases relative to EXP3, particularly in impacts to their Refuge Habitat and Food Availability and Quality.

The impacts of these changes are difficult to quantify on CCV steelhead. Increased flows could facilitate floodplain inundation, offering greater foraging opportunities and refuge from predation, improving water quality for the CCV steelhead and their prey, or transporting more prey downstream to be foraged upon. However, inflated summer flows could also disrupt the aquatic food web by reducing essential prey and favoring less nutritious species (Jeffres et al. 2020). Additionally, higher flows could create habitat more conducive to non-native competitors and predators, scour away food sources in some areas, and physically displace juvenile CCV steelhead downstream. This final factor, quantified as the velocity tolerances of juveniles, is likely the best represented variable in the BA's habitat modeling, which is based on habitat suitability determined from field studies of the distributions of rearing juveniles with respect to flow velocities, depths, and substrate (Appendix O – Tributary Habitat Attachment XX in U.S. Bureau of Reclamation 2023-2024). The limitations of this model are discussed in the BA (Assumptions/Uncertainty in U.S. Bureau of Reclamation 2023-2024) and the CCV Steelhead Exposure and Response to Shasta Fall and Winter Operations section (Section 7.1.1.2.2.4.3).

Particularly relevant in this case is that the velocity preferences of late fall-run Chinook salmon rearing from March to June were used as a surrogate in the model for CCV steelhead rearing in April through October (Tables X-3 and X-4 in U.S. Bureau of Reclamation 2023-2024). The habitat suitability curves indicate that CCV steelhead maximum habitat in Segment 5 (from ACID Dam to Cow Creek) occurs at about 4,000 cfs and declines rapidly as flows approach 8,000 cfs (Appendix O – Tributary Habitat Attachment XX, Figure X-4 in U.S. Bureau of Reclamation 2023-2024). The other segments do not have an optimum and are relatively unresponsive to flows across the range modeled. The median Sacramento River Flow downstream of Keswick Reservoir in July under the proposed action is 13,222 cfs, similar to the 13,307 anticipated under the NAA, but much more than the 8,728 cfs anticipated under EXP3 (Figure 58 and Appendix O, Tributary Habitat Attachment XX, Table X-12 in U.S. Bureau of Reclamation 2023-2024). The severity of the stressor is sublethal (lack of refuge habitat forces juvenile salmon into the open, increasing their vulnerability to predators and reducing their ability to conserve energy, leading to slower growth and potentially lower survival rates. Poor food availability and quality can also cause nutritional deficiencies, weakening the salmon and making them more susceptible to disease and stress), the proportion of the population exposed is medium (the upstream reach of the Sacramento River especially impacted by Shasta Dam operations serves as rearing habitat for a proportion of CCV steelhead juveniles), the frequency of exposure is medium (with measurable effects in most water years), the magnitude of effect is medium, and the weight of evidence is medium (since the impacts on foraging and diet are well documented but a surrogate is used for this line of evidence).



*All scenarios are simulated at 2022 Median climate condition and 15 cm sea level rise.

Figure 58. Sacramento River flow downstream of Keswick Reservoir, July.

Source: Appendix F, Figure F.2.2-3-16 in (U.S. Bureau of Reclamation 2023-2024)

7.1.1.2.4.2.4. Southern Distinct Population Segment of Green Sturgeon Exposure and Response

The timing of Summer Cold Water Pool Management coincides with the peak of egg, larval, and juvenile sDPS green sturgeon presence in the Upper Sacramento River. Occurring from April to July, sDPS green sturgeon spawning in the Sacramento River extends from Cottonwood Creek just downstream of Balls Ferry to Hamilton City (Poytress et al. 2015).

7.1.1.2.4.2.4.1. Egg Incubation

As noted in the BA (U.S. Bureau of Reclamation 2023-2024), "Green sturgeon embryo hatching success is maximized between 57.2 and 62.6°F and acceptable between 52 and 63°F." In general, the proposed action is expected to expose green sturgeon eggs and embryos to suboptimal conditions that could slow growth and development, but conditions are still within the acceptable range.

The percent of months from April through July outside the 52.3°F to 60.8°F water temperature range supporting sDPS green sturgeon egg incubation in the Sacramento River at Bend Bridge averaged across all years is anticipated to be 3 percent under the proposed action, 5 percent under the NAA, and 8 percent under EXP3. (Tables 4 and 5 in U.S. Bureau of Reclamation 2023-2024). The severity of the stressor is lethal (excessive water temperatures can be lethal to

green sturgeon egg incubation because they disrupt embryonic development, leading to abnormalities, reduced hatching success, and increased mortality), the proportion of the population exposed is large (current spawning activity is concentrated in the Sacramento River, with some documentation in the Feather and Yuba Rivers), the frequency of exposure is medium (with measurable effects in wet water years and small effects in dry and critical years), the magnitude of effect is high, and the weight of evidence is high (since this reach of the Sacramento River has a network of temperature gauges and fish monitoring to determine their exposure to this stressor).

For sDPS green sturgeon larvae, the BA (U.S. Bureau of Reclamation 2023-2024) summarizes that "In laboratory studies, water temperatures greater than 64.4°F (18°C) have been found to be detrimental to newly hatched larvae, with notochord deformities occurring between 68 and 78.8°F (20°C and 26°C, Linares-Casenave et al. 2013). Post yolk-sac larvae exhibited accelerated growth at higher temperatures of 75.2°F (24°C) when food was maintained in the lab. In the field, yolk-sac larvae have been collected between 55.2°F and 55.8°F (12.9°C and 13.2°C; Brown 2007, Poytress et al. 2015), but temperatures are held at approximately 56°F in these areas. Zarri et al. (2019) noted that warmer temperatures were associated with fuller stomachs and improved body condition but did not indicate an optimal temperature." The percent of months from May through August above the 64.4°F upper water temperature limit for newly hatched sDPS green sturgeon larvae at the Sacramento River are minimal at Bend Bridge, but substantial at Hamilton City. Averaged across all years, exceedances at Bend Bridge are anticipated in less than 1 percent of months for both the proposed action and the NAA, and 0 percent of months for EXP3. Exceedances at Bend Bridge under the proposed action are only expected to occur in critical years, during about 5 percent of months. On the other hand, exceedances at Hamilton City are expected in 35 percent of months under the proposed action, which is less than 39 percent of months under the NAA and 73 percent of months under EXP3. There is also a somewhat complicated relationship between hydrology (measured by water year type) and these temperature exceedances at Hamilton City under the proposed action, with the highest percentage of exceedances in critical years (65 percent), followed by wet years (35 percent), and then the remaining water years types (in the 26–27 percent range (Tables 6 and 7 in U.S. Bureau of Reclamation 2023-2024). The severity of the stressor is lethal (excessive temperatures kill newly hatched green sturgeon larvae by disrupting their development, increasing metabolic stress, reducing oxygen availability, causing cellular damage, increasing disease susceptibility, reducing food availability, and degrading their habitat.), the proportion of the population exposed is large (the Sacramento River is central habitat for spawning and early life stages of sDPS green sturgeon), the frequency of exposure is medium, the magnitude of effect is medium (only impacting critical water years at Bend Bridge, but all water year types at Hamilton City), and the weight of evidence is medium (the presence of temperature gauges and fish monitoring in this reach of the Sacramento River provide a moderate level of evidence for assessing the impact of temperature stressors on sDPS green sturgeon).

7.1.1.2.5. Sacramento River Division Effects Analysis Summary

The document above presented the relevant conceptual models, deconstructed the proposed action, and analyzed species exposure and response. This section will now synthesize the temperature effects and summarize the stressors described above for each species. Flow and temperature regimes are key components of the life history and diversity of fishes in lotic ecosystems. In Central Valley rivers, the remaining habitat accessible to anadromous fishes is at

lower elevations where temperatures can be limiting. The temperature effects of the proposed action are summarized in Table 27, Table 28, Table 29, and Table 30. The effects analysis results suggest that water temperature will be a high-magnitude stressor on SR winter-run Chinook salmon. HEC-5Q daily temperature estimates were downscaled from CalSim 3 and applied in the BA as inputs for certain models (e.g., TDM). However, most life history endpoints for temperature were analyzed and reported in the BA on a monthly time step. The temperature impacts summarized below, therefore, are relatively optimistic since they do not account for more acute (e.g., daily and weekly) impacts.

7.1.1.2.5.1. Synthesis of Temperature Impacts

Table 27. Water temperature effects of the proposed action (PA) on the Sacramento River for Sacramento River winter-run Chinook salmon.

Species	**Sacramento River winter-run Chinook salmon**						
Life Stage	adult spawning and holding		adult pathogen susceptibility		juvenile rearing and out-migration		
Timeframe	January - July				July - December		
Temperature Target	42.1°F to 55°F		59.9°F		55.4°F to 68°F		
Location	Keswick Dam	CCR Gauge	Keswick Dam	CCR Gauge	Keswick Dam	Red Bluff Diversion Dam	Hamilton City
Source*	BA Table 7	BA Table 8	BA Table 9	BA Table 10	BA Table 24	BA Table 25	BA Table 26
% Months Outside (PA)	2%	10%	0%	0%	93%	38%	33%

CCR = Sacramento River above Clear Creek gauge.

*sources are from Reclamation (2023-2024)

Table 28. Water temperature effects of the proposed action (PA) on the Sacramento River for Central Valley spring-run Chinook salmon.

Species	**Central Valley spring-run Chinook salmon**					
Life Stage	adult migration and spawning		adult pathogen susceptibility		yearling rearing	
Timeframe	April - October				April - December	
Temperature Target	42.1°F to 55°F		59.9°F		55.4°F to 68°F	
Location	Keswick Dam	Red Bluff Diversion Dam	Keswick Dam	Red Bluff Diversion Dam	Keswick Dam	Red Bluff Diversion Dam

Species	Central Valley spring-run Chinook salmon					
Source*	BA Table 8	BA Table 9	BA Table 11	BA Table 12	BA Table 20	BA Table 21
% Months Outside (PA)	7%	96%	3%	23%	94%	27%

*sources are from Reclamation (2023-2024)

Table 29. Water temperature effects of the proposed action (PA) on the Sacramento River for California Central Valley steelhead.

Species	California Central Valley steelhead														
Life Stage	adult migration, pathogen susceptibility			adult spawning		adult migration pathogen virulence		kelt emigration pathogens	egg incubation		egg incubation and fry emergence		juvenile out-migration	juvenile rearing and out-migration pathogens	
Timeframe	July - March			December - May				Feb. - June	December - June				Jan. - May	Year-round	
Temperature Target	59.9°F			41°F to 55°F		59.9°F			45°F to 52°F		59.9°F		55°F	59.9°F	
Location	Keswick Dam	Hamilton City	Red Bluff Diversion Dam	Keswick Dam	Red Bluff Diversion Dam	Keswick Dam	Red Bluff Diversion Dam	Red Bluff Diversion Dam	Keswick Dam	Red Bluff Diversion Dam	Keswick Dam	Red Bluff Diversion Dam	Red Bluff Diversion Dam	Keswick Dam	Red Bluff Diversion Dam
Source*	BA Table 10	BA Table 11	BA Table 12	BA Table 18	BA Table 19	BA Table 24	BA Table 25	BA Table 36	BA Table 42	BA Table 43	BA Table 48	BA Table 49	BA Table 66	BA Table 59	BA Table 60
% Months Outside (PA)	2%	35%	8%	3%	34%	0%	9%	18%	35%	54%	0%	13%	41%	2%	14%

*sources are from Reclamation (2023-2024)

Table 30. Water temperature effects of the proposed action (PA) on the Sacramento River for sDPS green sturgeon.

Species	Green sturgeon	
Life Stage	egg incubation	larvae post-hatch
Timeframe	April - July	May - August

Species	Green sturgeon			
Temperature Target	52.3°F to 60.8°F		64.4°F	
Location	Bend Bridge	Hamilton City	Bend Bridge	Hamilton City
Source*	BA Table 4	BA Table 5	BA Table 6	BA Table 7
% Months Outside (PA)	3%	76%	1%	35%

*sources are from Reclamation (2023-2024)

Climate change impacts will also be superimposed on the temperature effects described above. A sensitivity analysis was completed to analyze conditions under four broad climate scenarios: 2022 Median, 2022 Hot and Dry, 2022 Warm and Wet, and 2040 Median (Appendices 2021 LTO Climate Sensitivity Analysis – Alt2v1 wo TUCP in U.S. Bureau of Reclamation 2023-2024). Under the proposed action, relative to 2022 Median climate conditions, Shasta storage at both the end of April and the end of September is anticipated to be higher under 2022 Warm and Wet conditions. However, the reservoir storage is anticipated to be lower under the 2022 Hot and Dry and 2040 Median climates. In other words, there will be an increase in Shasta Reservoir storage in warmer, wetter conditions and a decrease in hotter, drier, and future conditions, when compared to the 2022 Median climate. Moreover, under the proposed action, with 2022 Hot and Dry conditions, Shasta end of September storage will be reduced to deadpool (when water can no longer flow downstream from the dam) 20 percent of the time. To avoid this frequency of deadpool conditions, operational adjustments would likely be necessary.

7.1.1.2.5.2. Summary of Sacramento River Division Stressors by Species

The impacts of temperature, along with other stressors, are summarized in Table 31 through Table 46, organized by species, and split into multiple sections for display in the document. In cases where there is more than one stressor effect, the most frequent or highest magnitude effect is displayed in the table, but the less frequent effect is noted under the expected change of fitness and discussed above in the body of the document. These summaries do not include the climate change stressor, since that was modeled separately via the aforementioned sensitivity analysis.

7.1.1.2.5.2.1. Summary of Sacramento River Division Winter-Run Chinook Salmon Stressors

The following tables summarize the effects of the proposed action on SR winter-run Chinook salmon. Summaries of Sacramento River long-term operations effects on SR winter-run Chinook salmon stressors are described for adult holding and spawning (Table 31), egg incubation to fry emergence (Table 32), and juvenile rearing to out-migration (Table 33). Table 34 describes the life stages, primary stressors and effect pathways and relevant management actions for each operational season on the Sacramento River. The purpose of Table 34 is to succinctly summarize the primary consequences of the proposed action without comparison to other scenarios or conditions. The effects that are summarized in Table 34 will also be carried forward to the Integration and Synthesis section of this opinion.

Table 31. Summary of Sacramento River long-term operations effects on Sacramento River winter-run Chinook salmon stressors for adult holding and spawning (April to September).

Stressor	Individual Response and Rationale of Effect	Severity of Stressor	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence
Water temperature	Water temperature and dissolved oxygen impact metabolism and survival	Lethal	Large	Low	High	Medium
Pathogens and disease	Pathogens and disease from river temperatures	Sublethal	Large	Low	Medium	Medium
Spawning habitat	Decreased spawning habitat	Sublethal	Small	Medium	Low	Medium

Table 32. Summary of Sacramento River long-term operations effects on Sacramento River winter-run Chinook salmon stressors for egg incubation to fry emergence (April to November).

Stressor	Individual Response and Rationale of Effect	Severity of Stressor	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence
Water temperature	Temperature dependent mortality of eggs	Lethal	Large	Medium	High	High
Redd quality	Altered Dissolved oxygen and sedimentation in redds	Lethal	Large	High	High	Medium

Table 33. Summary of Sacramento River long-term operations effects on Sacramento River winter-run Chinook salmon stressors for juvenile rearing to out-migration (July to February).

Stressor	Individual Response and Rationale of Effect	Severity of Stressor	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence
Stranding risk	Trapped juveniles after flow reductions	Lethal	Medium	High	High	High
Out-migration cues	Reduction in out-migrations cues, rates and survival	Lethal	Medium	Low	High	High

Stressor	Individual Response and Rationale of Effect	Severity of Stressor	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence
Water temperature and dissolved oxygen	Water temperature and dissolved oxygen impact metabolism and survival	Lethal	Small	Low	Low	High
Refuge habitat	Decrease in refuge habitat from changes in flow velocities.	Sublethal	Large	Medium	Medium	Medium
Food availability and quality	Decrease flows resulting in a change of food web processes and likely a decrease in quality food available	Sublethal	Large	Medium	Medium	Medium

Table 34. Summary of primary affected Sacramento River winter-run Chinook salmon life stages, primary stressors/effect pathways, and relevant management actions for seasonal operations periods. These are the elements that will be incorporated into the Integration and Synthesis section of this opinion.

Seasonal Operations Period	Affected Life Stage	Summary of Primary Stressors and Effects of the Proposed Action	Relevant Management Actions
Fall and Winter Operations	Incubating eggs and Juveniles	Stranding and Dewatering ● Up to 4,375 juveniles/year ● Up to 1 redd per/year	Ramping rates, fall and winter baseflows for Shasta Refill and Redd maintenance
	Juveniles	Out-migration cues, Juvenile growth and survival ● Survival effects during out-migration	Winter base flows and Pulse flows
Spring Operations	Migrating and Holding adults	Pathogens and disease, pre-spawning mortality ● Up to 5.5% female pre-spawning, although less than 3% expected	Adult Migration Holding Temperature Objectives

Seasonal Operations Period	Affected Life Stage	Summary of Primary Stressors and Effects of the Proposed Action	Relevant Management Actions
	Adult spawning	Spawning Habitat ● Amount and location of spawning habitat ranges managed in relation to the CCR gauge based on Bin Objectives	Shasta Framework, annual Temperature Management Plans, technical and policy team coordination during real-time operations, and adaptive management
	Incubating eggs	Redd Quality ● Quality of spawning habitat conditions managed in relation to the CCR gauge based on Bin Objectives	Shasta Framework, annual Temperature Management Plans, technical and policy team coordination during real-time operations, and adaptive management
	Juveniles	Out-migration cues ● Survival effects during out-migration	Pulse flows
Summer Operations	Adult spawning and egg incubation	Water temperature, pathogens and disease ● Affected by Shasta Framework based on Bin Objectives	Shasta Framework, annual Temperature Management Plans, technical and policy team coordination during real-time operations, and adaptive management
	Adult spawning	Spawning habitat ● Affected by Shasta Framework based on Bin Objectives	Shasta Framework, annual Temperature Management Plans, technical and policy team coordination during real-time operations, and adaptive management
	Incubating eggs	Redd quality ● Affected by Shasta Framework based on Bin Objectives	Shasta Framework, annual Temperature Management Plans, technical and policy team coordination during real-time operations, and adaptive management

7.1.1.2.5.2.1.1. Summary of Sacramento River Division Central Valley Spring-Run Chinook Salmon Stressors

The following tables summarize the effects of the proposed action on CV spring-run Chinook salmon. Summaries of Sacramento River long-term operations effects on CV spring-run Chinook salmon stressors are described for adult holding and spawning (Table 35), egg incubation to fry emergence (Table 36), juvenile rearing to out-migration (Table 37), yearling rearing (Table 38), and yearling migration (Table 39). Table 40 describes the life stages, primary stressors and effect pathways, and relevant management actions for each operational season on the Sacramento

River. The purpose of Table 40 is to succinctly summarize the primary consequences of the proposed action without comparison to other scenarios or conditions. The effects that are summarized in Table 40 will also be carried forward to the Integration and Synthesis section of this opinion.

Table 35. Summary of Sacramento River long-term operations effects on Central Valley spring-run Chinook salmon stressors for adult holding and spawning (March to September).

Stressor	Individual Response and Rationale of Effect	Severity of Stressor	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence
Water temperature	Water temperature and dissolved oxygen impact metabolism and survival	Lethal	High	High	High	High
Pathogens and disease	The occurrence of pathogen virulence is diminished in cooler waters	Sublethal	Large	High	High	Medium
Spawning habitat	Decreased spawning habitat from changes in river flows resulting from Keswick releases.	Lethal	Small	High	High	High

Table 36. Summary of Sacramento River long-term operations effects on Central Valley spring-run Chinook salmon stressors for egg incubation to fry emergence (September to February).

Stressor	Individual Response and Rationale of Effect	Severity of Stressor	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence
Stranding and dewatering	Egg or Fry Mortality	Lethal	Medium	High	High	Medium
Water temperature	Water temperature and dissolved oxygen impact metabolism and survival	Sub-lethal	Medium	High	High	High
Redd quality	Impaired respiration resulting from sedimentation and lower water column dissolved oxygen.	Sub-Lethal	Medium	High	Medium	Medium

Table 37. Summary of Sacramento River long-term operations effects on Central Valley spring-run Chinook salmon stressors for juvenile rearing to out-migration (November to June).

Stressor	Individual Response and Rationale of Effect	Severity of Stressor	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence
Stranding risk	Increased mortality of tapped juveniles in habitat disconnected from the main stem.	Lethal	Medium	Medium	High	High
Out-migration cues	Reduction in out-migrations cues, rates and survival	Sublethal	Large	High	High	Medium
Refuge Habitat	Decreased flows in the Sacramento River thereby reducing suitable margin and off-channel habitats available as refuge habitat for juveniles.	Sublethal	Large	Low	Medium	High
Food availability and quality	Decrease flows resulting in a change of food web processes and likely a decrease in quality food available	Sublethal	Large	High	High	High

Table 38. Summary of Sacramento River long-term operations effects on Central Valley spring-run Chinook salmon stressors for juvenile rearing to out-migration (November to June).

Stressor	Individual Response and Rationale of Effect	Severity of Stressor	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence
Stranding risk	Increased mortality of tapped juveniles in habitat disconnected from the main stem.	Lethal	Medium	High	High	High
Water temperature and dissolved oxygen	Water temperature and dissolved oxygen impact metabolism and survival	Lethal	Small	High	High	Medium
Refuge habitat	A decrease of flows may reduce suitable margin and off-channel habitats available as refuge habitat for yearlings	Sublethal	Small	Medium	Low	Medium

Table 39. Summary of Sacramento River long-term operations effects on Central Valley spring-run Chinook salmon stressors for yearling migration (October to March).

Stressor	Individual Response and Rationale of Effect	Severity of Stressor	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence
Stranding risk	Increased mortality of trapped yearlings in habitat disconnected from the main stem.	Lethal	Small	High	Medium	High
Out-migration cues	Reduction in out-migrations cues, rates and survival	Sublethal	Large	High	High	Medium
Refuge habitat	Decreased flows in the Sacramento River thereby reducing suitable margin and off-channel habitats available as refuge habitat for yearling out-migrants.	Sublethal	Large	Low	Medium	High
Food availability and quality	Growth rates and altered behavior resulting in predation risk	Sublethal	Large	Low	Medium	High

Table 40. Summary of primary affected Central Valley spring-run Chinook salmon life stages, primary stressors/effect pathways, and relevant management actions for seasonal operations periods. These are the elements that will be incorporated into the Integration and Synthesis section of this opinion.

Division/ Waterbody	Seasonal Operations Period	Affected Life Stage	Summary of Primary Stressors and Effects of the Proposed Action	Relevant Management Actions
Sacramento River	Fall and Winter Operations	Adult spawning	Spawning Habitat ● Amount and extent of potential habitat affected by water temperatures that are driven by annual temperature management plans that target SR winter-run Chinook salmon. Also influenced by Bin type.	Shasta Framework, annual Temperature Management Plans, technical and policy team coordination during real-time operations, and adaptive management

Division/ Waterbody	Seasonal Operations Period	Affected Life Stage	Summary of Primary Stressors and Effects of the Proposed Action	Relevant Management Actions
		Incubating eggs	Redd Quality ● Amount and extent of potential habitat downstream of Sacramento River winter-run Chinook salmon temperature compliance reach expected to result in egg mortality downstream of water temperature zones in annual temperature management plans. May also occur during the month of November when the temperature management season concludes.	Shasta Framework, annual Temperature Management Plans, technical and policy team coordination during real-time operations, and adaptive management
	Spring Operations	Juvenile rearing and out-migration	Out-migration Cues ● Springtime survival from Deer Creek Confluence to the Feather River Confluence is expected to be 11 to 26%, from critical to wet years.	Pulse Flows, Shasta Framework, annual Temperature Management Plans, technical and policy team coordination during real-time operations, and adaptive management
	Summer Operations	Adult Spawning	Spawning Habitat ● Potential for dewatering of some early redds in August following peak managed releases in July.	Shasta Framework, annual Temperature Management Plans, technical and policy team coordination during real-time operations, and adaptive management

7.1.1.2.5.2.2. Summary of Sacramento River Division California Central Valley Steelhead Stressors

The following tables summarize the effects of the proposed action on CCV steelhead. Summaries of Sacramento River long-term operations effects on CCV steelhead stressors are described for adult migration and holding, adult spawning, and kelt emigration (Table 41), egg incubation to fry emergence (Table 42), and juvenile rearing to out-migration (Table 43). Table 44 describes the life stages, primary stressors and effect pathways, and relevant management actions for each operational season on the Sacramento River. The purpose of Table 44 is to succinctly summarize the primary consequences of the proposed action without comparison to other scenarios or

conditions. The effects summarized in Table 44 will also be carried forward to the Integration and Synthesis section of this opinion.

Table 41. Summary of Sacramento River long-term operations effects on California Central Valley steelhead stressors for adult migration and holding (July to March), adult spawning (December to April), and kelt emigration (December to June).

Stressor	Individual Response and Rationale of Effect	Severity of Stressor	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence
Pathogens and Disease (Adult Migration and Holding)	Water temperature and dissolved oxygen impact metabolism and survival	Lethal	Small	Low	Low	Medium
Water temperature (Adult Spawning)	Water temperature and dissolved oxygen impact metabolism and survival	Sub-lethal	Small	High	Medium	Medium
Pathogens and disease (Adult Spawning)	The occurrence of pathogen virulence is diminished in cooler waters	Lethal	Small	Low	Low	High
Spawning habitat (Adult Spawning)	Decreased spawning habitat from changes in river flows resulting from Keswick releases.	Lethal	Small	Low	Low	Medium
Pathogens (Kelt Emigration)	The occurrence of pathogen virulence is diminished in cooler waters	Lethal	Medium	High	High	High

Table 42. Summary of Sacramento River long-term operations effects on California Central Valley steelhead stressors for egg incubation to fry emergence (December to June).

Stressor	Individual Response and Rationale of Effect	Severity of Stressor	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence
Stranding and dewatering	Mortality of incubating eggs	Lethal	Small	High	Medium	Medium
Water temperature	Water temperature and dissolved oxygen impact metabolism and survival	Lethal	Small	High	Medium	High

Stressor	Individual Response and Rationale of Effect	Severity of Stressor	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence
Pathogens and Disease	Warmer water temperatures may increase pathogen virulence and prevalence of disease.	Lethal	Medium	Medium	High	Medium

Table 43. Summary of Sacramento River long-term operations effects on California Central Valley (CCV) steelhead stressors for juvenile rearing to out-migration (year-round).

Stressor	Individual Response and Rationale of Effect	Severity of Stressor	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence
Stranding risk	Increased mortality of trapped juveniles in habitat disconnected from the main stem.	Lethal	Medium	High	High	High
Out-migration cues	Reduction in out-migrations cues, rates and survival.	Sublethal	Large	Medium	Medium	Medium
Pathogens and disease	The occurrence of pathogen virulence is diminished in cooler waters.	Lethal	Medium	Medium	High	Medium
Refuge habitat	Decreased flows in the Sacramento River thereby reducing suitable margin and off-channel habitats available as refuge habitat for juveniles.	Sublethal	Medium	Medium	Medium	Medium
Food availability and quality	Decreased quality and quantity of food due to flow alterations for foraging juvenile California Central Valley steelhead will impact growth rates. Additionally, food limitation can weaken juvenile CCV steelhead, leading to extremes such as starvation, and alter behavior resulting in predation risk.	Sublethal	Medium	High	Medium	High

Table 44. Summary of primary affected California Central Valley steelhead life stages, primary stressors/effect pathways, and relevant management actions for seasonal operations periods. These are the elements that will be incorporated into the Integration and Synthesis section of this opinion.

Division/Water body	Seasonal Operations Period	Affected Life Stage	Summary of Primary Stressors and Effects of the Proposed Action	Relevant Management Actions
Sacramento River	Fall and Winter Operations	Adult spawning and egg incubation	Water temperature ● May exceed optimal thermal conditions in 4% of months in critical years	Shasta Framework, annual Temperature Management Plans, technical and policy team coordination during real-time operations, and adaptive management
	Spring Operations	Juvenile rearing and out-migration	Stranding Risk ● Highest in February and March ● low of 3,544 in dry years (with caveats described above that these are likely overestimates) ● High of 7,973 in wet years (with caveats described above that these are likely overestimates	Ramping rates
	Summer Operations	Adults and rearing juveniles	Pathogens and Disease ● 59.9 threshold exceeded in 13.5% of months in critical years	Shasta Framework, annual Temperature Management Plans, technical and policy team coordination during real-time operations, and adaptive management

7.1.1.2.5.2.3. Summary of Sacramento River Division Green Sturgeon Stressors

The following tables summarize the effects of the proposed action on sDPS green sturgeon. The Sacramento River long-term operations effects on sDPS green sturgeon stressors are described for egg incubation, larvae, and juveniles (Table 45). Table 46 describes the life stages, primary stressors and effect pathways, and relevant management actions for each operational season on the Sacramento River. The purpose of Table 46 is to succinctly summarize the primary consequences of the proposed action without comparison to other scenarios or conditions. The effects that are summarized in Table 46 will also be carried forward to the Integration and Synthesis section of this opinion.

Table 45. Summary of Sacramento River long-term operations effects on green sturgeon egg incubation (April to June), larvae (April to August), and juveniles (October to January).

Stressor	Individual Response and Rationale of Effect	Severity of Stressor	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence
Water Temperature	Embryo hatching success	Lethal	Large	Medium	Large	High
Water Temperature	Water temperature and dissolved oxygen impact metabolism and survival	Lethal	Large	Medium	Medium	Medium
Stranding Risk	Stranding of juveniles	Lethal	Small	High	Medium	High

Table 46. Summary of primary affected life stages, primary stressors/effect pathways, and relevant management actions for seasonal operations periods. These are the elements that will be incorporated into the Integration and Synthesis section of this opinion.

Division/ Waterbody	Seasonal Operations Period	Affected Life Stage	Summary of Primary Stressors and Effects of the Proposed Action	Relevant Management Actions
Sacramento River	Fall and Winter Operations	Adult migration	Adult migration cues could reduce strength of migration cues	Fall and winter baseflows for Shasta Refill and Redd maintenance
	Spring Operations	Adult migration	Adult migration cues could reduce strength of migration cues	Fall and winter baseflows for Shasta Refill and Redd maintenance
	Summer Operations	Adult spawning and egg incubation	Spawning habitat ● Colder than optimal water temperatures may slow growth and development	Affected by Shasta Framework based on Bin Objectives

7.1.2. Effects of the Action on Critical Habitat

Critical habitat impacted by the proposed action includes the Sacramento River from Keswick Dam to the I Street Bridge in Sacramento, where the Bay-Delta Division continues. This stretch of the Sacramento River provides three general habitat types essential to one or more life stages, including freshwater spawning sites, rearing sites, and migration corridors for SR winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead and sDPS green sturgeon.

7.1.2.1. Effects to Chinook Salmon Critical Habitat Physical and Biological Features

This section examines the impacts to designated critical habitat for SR winter-run Chinook salmon, CV spring-run Chinook salmon, and CCV steelhead. Critical habitat for both CV spring-run Chinook salmon and CCV steelhead was designated concurrently, and they share the same PBFs. The PBFs for SR winter-run Chinook salmon are related and similar to the habitat types of the other listed salmonids, but they were described with more specificity at designation. Here, the general habitat types that occur within the Division provide the structure for the assessment of habitat impacts for all salmonids. For each habitat type and each fish species, the specific PBFs that correspond to ESA-listed critical habitat are identified. Where there are discussions of the effects to a specific component of a PBF, these are delineated by species. As effects to individual fish are intrinsically linked to what life stage is present at the time of the exposure and the condition of the habitat to support that life stage, we use the species effects analysis conclusions (exposure and response) as the foundation for our analysis of effects to critical habitat. For example, as the effects of riparian removal on rearing juveniles are likely to result in reduced growth/survival, the effects to critical habitats would be described in terms of the PBFs affected for that life stage, thereby resulting in degraded rearing habitat.

7.1.2.1.1. Effects to Habitat for Spawning Adults, Incubation of Eggs, and Rearing for Fry

7.1.2.1.1.1. Sacramento River Winter-Run Chinook Salmon Physical and Biological Features

- Availability of clean gravel for spawning substrate
- Adequate river flows for successful spawning, incubation of eggs, fry development and emergence, and downstream transport of juveniles
- Water temperatures between 42.5°F and 57.5°F (5.8°C –14.1°C) for successful spawning, egg incubation, and fry development

7.1.2.1.1.2. Central Valley Spring-Run Chinook Salmon and California Central Valley Steelhead Physical and Biological Features

- Freshwater Spawning Sites

Freshwater spawning habitat for all three species occurs in the upper reaches of the Sacramento River from Keswick Dam to Red Bluff Diversion Dam. The available spawning area for salmonids in this region is greatly limited by the existence of impassable barriers like Keswick and Shasta dams. Spawning habitat is further constrained by the availability of suitable temperatures during each species' respective spawning season, such that in the Sacramento River, spawning is limited to a small area below Keswick Dam.

The existence of Shasta and Keswick dams also limits the recruitment of clean gravel for spawning substrate as they block the downstream transport of gravels to the accessible reach of the river. Clean gravel is available from upstream supply deposited from tributaries and gravel augmentation projects and from flows high enough to flush finer sediment out of gravel beds, but not so high as to transport gravel out of the spawning area. Long-term average flows under the proposed action are generally similar to the NAA and EXP3 at Keswick Reservoir from February through April (from 6,279 to 11,711 cfs on average for NAA and from 5,341 to 11,751 cfs on average for EXP3) and are unlikely to affect the amount of upstream gravel supplied by the

tributaries or unregulated pulse flows during this time period. During the spring, Reclamation's proposed pulse flow, described in BA Section 3.1.7 (U.S. Bureau of Reclamation 2023-2024), could provide flows high enough to flush fine sediments from spawning substrates, but the expected frequency of these regulated flows is limited in the years that would not otherwise have a natural spring pulse. Additionally, the flow required for geomorphic benefits may be much greater than the magnitude of most managed pulses. For example, the most recent Sacramento River pulse flows, in the spring of 2024, utilized flows of about 12,000–13,000 cfs at Keswick Dam (Figure 59). Estimates indicate that below Keswick Dam, spawning gravel transport begins at 24,000 cfs, the minimum for full-scale bed mobilization is likely 50,000 cfs, and although Keswick Dam's maximum release is 79,000 cfs, some riffles may remain immobile even at greater than 100,000 cfs (small boulders and large cobbles may be armored due to years of erosion from sediment-free water released from Shasta Dam, Cain and Monohan 2008). The impact of the proposed action, particularly in wet years, is very impactful in December by altering geomorphic flows that can create spawning habitat and affect the peak of CV spring-run Chinook salmon egg incubation and the initiation of CCV steelhead spawning. Average flow in this month is about 9,000 cfs under the proposed action, slightly higher than the approximately 7,000 cfs expected under the NAA, but drastically less than about 21,000 cfs under EXP3. Although, in the short term, these lower flows could prevent the scour of CV spring-run Chinook salmon redds, it will have negative impacts on critical habitat PBFs for CV spring-run Chinook salmon, SR winter-run Chinook salmon, and CCV steelhead dependent on the geomorphic processes that maintain clean gravel for spawning substrate.

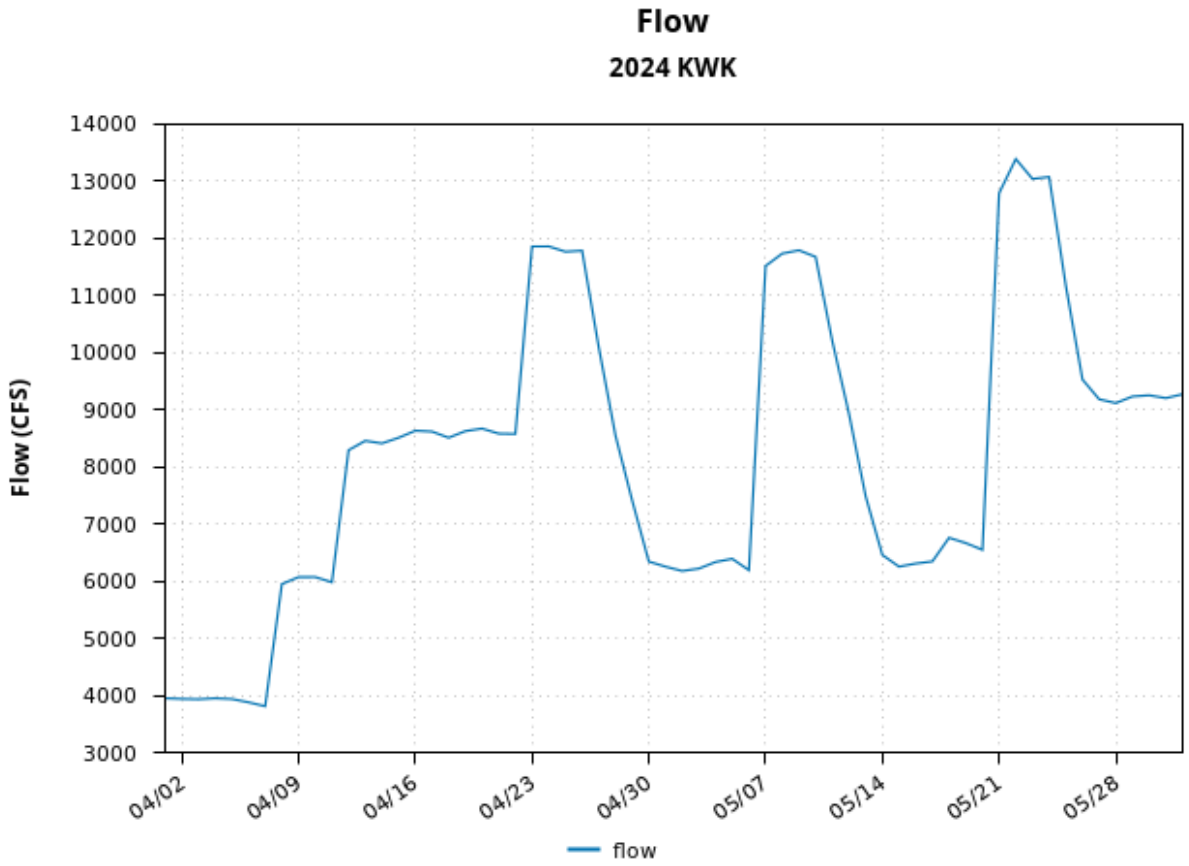
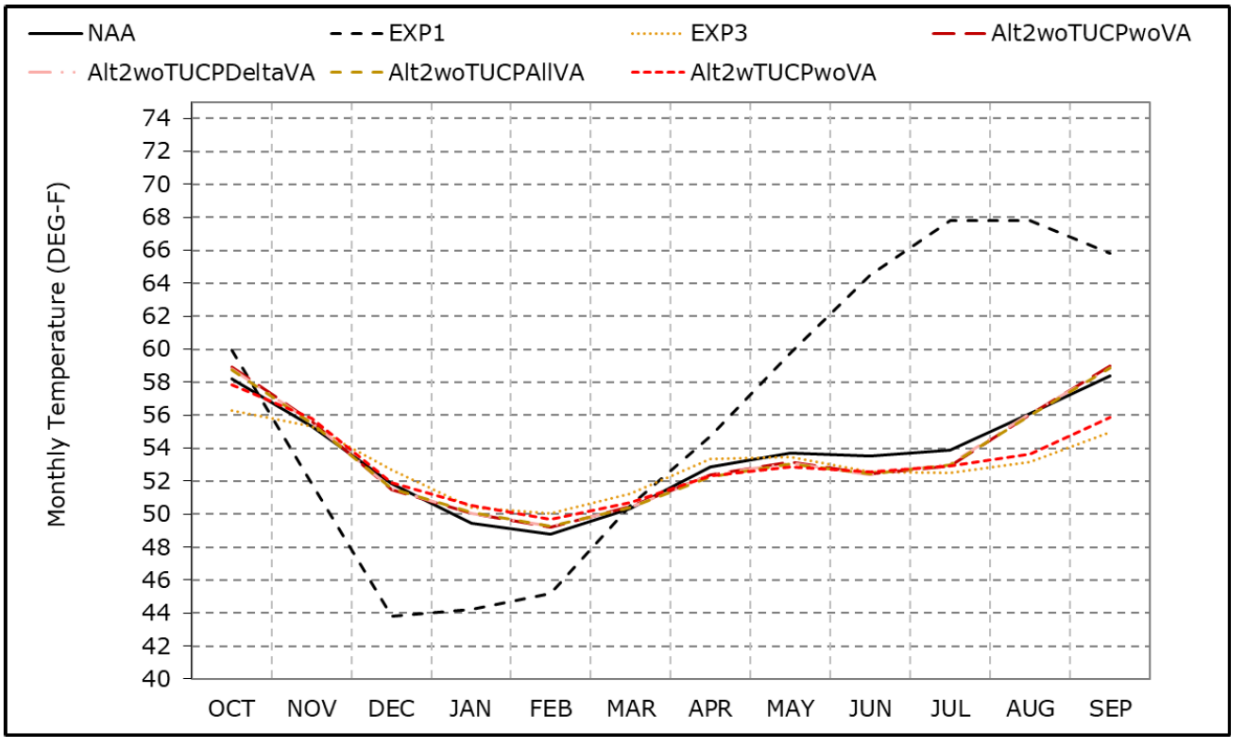


Figure 59. Flows (in cubic feet per second) in the Sacramento River at Keswick (KWK) Dam for April through May of 2024 showing the three managed Spring pulse flows.

Source: (University of Washington Columbia Basin Research 2024b). SacPAS River Environment Graphics & Text. Available from www.cbr.washington.edu/sacramento/data/query_river_graph.html

Water temperatures play a significant role in the function of salmonid spawning habitat. The proposed action can provide suitable temperatures for spawning, egg incubation, and fry development in many months and most wetter water years, but even with the prescience associated with the hydrologic modeling, there are still months and years when spawning, egg incubation, and fry development PBFs are degraded due to unsuitable water temperatures. This is expected to affect spawning success and survival of eggs and fry. The impacts to species of these temperature exceedances are described in Shasta Summer Operations (Section 7.1.1.2.4). Of particular concern are temperatures in the months of August–October, which corresponds to peak CV spring-run Chinook salmon spawning in the Upper Sacramento River. During critical years, these months tend to have the warmest water temperatures for the proposed action (Figure 60).



*As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).
*These results are displayed with calendar year - year type sorting.
*All scenarios are simulated at 2022 Median climate condition and 15 cm sea level rise.

Figure 60. Sacramento River below Keswick Dam, critical year average temperature (°F).

In summary, the proposed action adversely impacts the freshwater rearing habitat PBFs for juveniles and spawning adults PBFs for SR winter-run and CV spring-run Chinook salmon.

7.1.2.1.2. Effects to Freshwater Rearing Habitat Physical and Biological Features for Juveniles

7.1.2.1.2.1. Sacramento River Winter-Run Chinook Salmon

- Habitat areas and adequate prey that are not contaminated
- Riparian habitat that provides for successful juvenile development and survival

7.1.2.1.2.2. Central Valley Spring-Run Chinook Salmon and California Central Valley Steelhead

- Freshwater Rearing Sites

Freshwater rearing habitat occurs for all three salmonid species in the mainstem Sacramento River from Keswick Dam downstream to the Delta. The CVP operations influence water quality for Chinook salmon rearing habitat in the Sacramento River in several ways, primarily temperature, dissolved oxygen, and contaminants. Warmer water temperatures resulting from Shasta Reservoir operations can impact juvenile Chinook salmon by increasing their metabolic rate and energy demands, reducing their growth, and potentially increasing their susceptibility to disease. The water temperatures under the proposed action will not be supportive of juvenile

rearing for the majority of months during the peak months of the life stage, thereby degrading the PBF for rearing below Keswick Dam from July to December for winter-run juveniles (BA Table 24, U.S. Bureau of Reclamation 2023-2024) and from April to December for CV spring-run Chinook salmon yearlings (BA Table 20, U.S. Bureau of Reclamation 2023-2024).

The CVP's influence on dissolved oxygen levels is complex and can vary depending on the season and specific operations. In general, higher flows tend to result in increased dissolved oxygen levels, while lower flows and warmer temperatures can lead to decreased dissolved oxygen. Low dissolved oxygen in freshwater rearing habitat can stress the fish, impair their growth, and even lead to mortality in extreme cases. The CVP can also affect the concentration of contaminants in the Sacramento River. Reduced flows in the winter and spring can concentrate contaminants, while increased flows in the summer can dilute them. Additionally, high flows and pulse flows can mobilize sediments containing contaminants. Contaminants can have a range of negative effects on juvenile Chinook salmon, including reduced growth, impaired immune function, and increased susceptibility to disease.

The availability of freshwater riparian habitat PBFs that provide for successful juvenile development and survival is also affected by flow. Higher flows lead to greater inundation of the floodplain, creating more off-channel habitat and expanding the riparian zone with increased food availability and enhanced refuge habitat. Floodplain inundation promotes the growth of riparian vegetation and supports a diverse community of aquatic and terrestrial invertebrates, which are important food sources for juvenile salmon. Off-channel habitats and the expanded riparian zone offer refuge from predators and high flows, allowing juvenile salmon to conserve energy and reduce mortality. Conversely, low flows can reduce the availability of riparian habitat, limiting access to food and shelter and potentially exposing juvenile salmon to higher water temperatures and predation risk. This can negatively impact their growth, survival, and overall fitness.

The expected WUA for SR winter-run Chinook salmon fry rearing in the Sacramento River from Keswick Dam to the Battle Creek confluence, averaged across all years, is 247,705 under the proposed action, which is nearly indistinguishable from the 247,838 under the NAA, but somewhat less than the 265,748 anticipated under EXP3. The expected habitat for CV spring-run Chinook salmon rearing in the Sacramento River from Keswick Dam to the Battle Creek confluence across all water years under the proposed action, relative to EXP3, as measured by weighted usable area, is anticipated to decrease 7 percent for fry (from about 266,000 to about 248,000) and 2 percent for juveniles (from about 204,000 to about 200,000; Table X-19 and X-21, LTO Appendix O - Tributary Habitat Attachment XX, Sacramento River Weighted Usable Area Analysis in U.S. Bureau of Reclamation 2023-2024). There is also a decrease in the predicted mean rearing habitat quantities, in acres, for CV spring-run Chinook salmon in the Upper Sacramento River. When summed across all water years and months, modeling predicts a total loss of 62 acres of instream rearing (9-percent decrease) and 31 acres of floodplain rearing habitat (18-percent decrease; Tables 24 and 25 in LTO Appendix O - Tributary Habitat Attachment X, SIT LCM Habitat Estimates in U.S. Bureau of Reclamation 2023-2024). The decrease in Fremont Weir Spills and Yolo Bypass long-term average flows (Figures F.2.2-10-1 and F.2.2-11-1 in U.S. Bureau of Reclamation 2023-2024) will also reduce downstream habitat for juveniles. Decreased flows in the Sacramento River thereby reduce suitable margin and off-channel habitats available as refuge habitat for juveniles. Modeling indicates a decrease in rearing habitat. Proposed action flows are expected to decrease WUA by 2 percent for CCV

steelhead juvenile rearing in the Sacramento River from Keswick Dam to the Battle Creek confluence (from about 750,000 under EXP3 to 732,000 under the proposed action; Appendix O, Attachment XX, Table X-12 in U.S. Bureau of Reclamation 2023-2024). In summary, the proposed action adversely impacts the freshwater rearing habitat PBFs for juveniles and spawning adults PBFs for SR winter-run and CV spring-run Chinook salmon.

7.1.2.1.3. Freshwater Migratory Corridor Physical and Biological Features for Out-Migrating Juveniles and Spawning Adults

7.1.2.1.3.1. Sacramento River Winter-Run Chinook Salmon

- Adequate river flows for successful spawning, incubation of eggs, fry development and emergence, and downstream transport of juveniles
- Access from the Pacific Ocean to appropriate spawning areas in the Upper Sacramento River
- Access downstream so that juveniles can migrate from the spawning grounds to San Francisco Bay and the Pacific Ocean

7.1.2.1.3.2. Central Valley Spring-Run Chinook Salmon and California Central Valley Steelhead

- Freshwater Migration Corridors

Functioning migration corridor PBFs for the emigration of juvenile salmonids from the Upper Sacramento River to the Delta and for the immigration of adult salmonids to the Upper Sacramento River and its tributaries is dependent on the condition of flows, temperature, and the presence of impediments.

Flows in the Sacramento River for the proposed action are sufficient to maintain access both to and from the spawning habitat in the river below Keswick Dam. For out-migration, based on the Flow Threshold Salmon Survival Model, springtime (March 15 to June 15) juvenile out-migration survival in the mainstem Sacramento River (from the Deer Creek Confluence to the Feather River Confluence, as described in Michel et al. [2021]) is expected to be greatest in wet water years at 26 percent, and the least in critically dry water years at 11 percent. As proposed, a pulse flow occurring in the spring is expected to result in increased survival of CV spring-run Chinook salmon by mimicking the natural hydrologic cues that trigger salmonid out-migration and improve survival down their migration corridor. For Juvenile CCV steelhead, the storage of water associated with the proposed action may increase the out-migration cue stressor, particularly in the winter and spring from December through April.

In summary, the proposed action adversely impacts the freshwater migratory corridor PBFs for out-migrating juveniles and spawning adults PBFs for SR winter-run and CV spring-run Chinook salmon.

7.1.2.2. Effects to sDPS Green Sturgeon Critical Habitat Physical and Biological Features

Critical habitat for the sDPS green sturgeon includes PBFs that describe features of habitat types for multiple life stages. This section is structured similarly to the Effects to Chinook Salmon Critical Habitat Physical and Biological Features (Section 7.1.2.1). Specific PBFs that are present in the Shasta Division are identified within each general habitat type and described in the

context of each life stage. As effects to individual fish are intrinsically linked to what life stage is present at the time of the exposure and the condition of the habitat to support that life stage, we use the species effects analysis conclusions (exposure and response) as the foundation for our analysis of effects to critical habitat. For example, as the effects of riparian removal on rearing juveniles are likely to result in reduced growth/survival, the effect to critical habitat would be described in terms of the PBFs affected for that life stage, thereby resulting in degraded rearing habitat.

7.1.2.2.1. Habitat for Spawning Adults, Incubation of Eggs, and Rearing for Larvae sDPS Green Sturgeon Physical and Biological Features

- Water Quality
- Water Flow
- Substrate Type or Size

Spawning habitat occurs for sDPS green sturgeon in the upper reaches of the Sacramento River and is concentrated between Glenn Colusa Irrigation District/Hamilton City (river miles 206), upstream to near Inks Creek at river mile 264 (between the BND and JLF gauges) about 38 river miles downstream of Keswick Dam. Adult sDPS green sturgeon migrate upriver from March to early April, and spawn from April through July, with the median spawning in May (Poytress et al. 2015).

As discussed in Shasta Summer Operations (Section 7.1.1.2.4), modeled water temperatures in the Upper Sacramento River for the proposed action are expected to affect the critical habitat water quality PBF used by early life stages in the Sacramento River during some years. Generally, the percent of months outside the temperature targets for egg incubation and larvae post-hatch are sufficient in most water years at Bend Bridge, but insufficient for egg incubation and rearing habitat at Hamilton City (

Table 47). At Hamilton City, temperatures are frequently outside the temperature range that provide adequate habitat for egg incubation (76 percent of months) and newly hatched larvae (35 percent of months,

Table 47).

Table 47. Percent of months outside or above the water temperature range or limit supporting sDPS green sturgeon egg incubation and newly hatched larvae.

	52.3 - 60.8°F supporting temperature range from April through July for egg incubation			**64.4°F upper water temperature limit from May through August for newly hatched larvae**		
	At Bend Bridge					
WYT	**PA**	**NAA**	**EXP3**	**PA**	**NAA**	**EXP3**
W	9	10	18	0	0	0

	52.3 - 60.8°F supporting temperature range from April through July for egg incubation			64.4°F upper water temperature limit from May through August for newly hatched larvae		
AN	0	2	4	0	0	0
BN	0	1	3	0	0	0
D	1	3	3	0	0	0
C	2	5	5	5	5	0
All	3	5	8	1	1	0
	At Hamilton City					
WYT	**PA**	**NAA**	**EXP3**	**PA**	**NAA**	**EXP3**
W	67	69	77	36	41	80
AN	69	69	83	27	29	79
BN	71	71	88	26	29	68
D	81	81	96	26	30	62
C	94	97	97	66	70	81
All	76	77	87	35	39	73

WYT = Water Year Type; PA = Proposed Action; W = Wet; AN = Above Normal; BN = Below Normal; D = Dry; C= Critical

7.1.2.2.2. Freshwater Rearing Habitat for Juveniles and Subadults sDPS Green Sturgeon Physical and Biological Features

- Water Quality
- Water Flow
- Food Resources
- Sediment Quality
- Depth

Based on laboratory studies of northern DPS green sturgeon, the optimal bioenergetic performance for juvenile green sturgeon (including growth, metabolic rate, temperature preference, and swimming performance) occurs at 59°F to 66.2°F (Mayfield and Cech 2004); however, young juveniles have been found to maintain swimming performance across a wider range of temperatures, from 52°F to 63°F (Rodgers et al. 2019). Based on the May to October timing of larval and juvenile occurrence in the Sacramento River at Glenn Colusa Irrigation District (Poytress et al. 2015), the predicted range of water temperatures in the Sacramento River

for the proposed action is expected to have a beneficial effect on the water quality critical habitat PBF used by juveniles for rearing.

The PBF of water flow for sDPS green sturgeon critical habitat is also related to the food resources, sediment quality, and depth PBFs because water flow can determine access to the quantity and quality of the other PBFs in the freshwater rearing habitat. Changes to floodplain inundation is a metric used to measure the overall quantity of riparian habitat and the relative access to the PBFs of food resources, sediment quality, and depth. Results of the floodplain inundation analyses for the Fremont Weir spill showed no changes relative to the NAA, but a decrease in the monthly flow to the Yolo Bypass for the proposed action compared to the EXP3 from December to March (Figure F.2.2-10-1 in U.S. Bureau of Reclamation 2023-2024), with more pronounced effects in above normal, below normal and dry years, particularly in December. This is expected to provide a decrease in freshwater rearing habitat for juvenile sDPS green sturgeon.

7.1.2.2.3. Freshwater Migratory Corridor Physical and Biological Features for Out-Migrating Juveniles and Spawning Adults

- Migratory Corridor
- Sediment Quality
- Depth

Freshwater migratory corridors for sDPS green sturgeon are those migratory corridors linking the estuarine habitat in the Delta with the spawning habitat in upstream spawning reaches of the Sacramento River.

7.1.2.3. Summary of Effects of the Action on Critical Habitat

The effects of the action on critical habitat are summarized below in Table 48, Table 49, and Table 50.

Table 48. Sacramento River winter-run Chinook salmon summary of effects of the action on critical habitat compared to EXP3.

Life Stage	Action Component	Location of Effect	Physical and Biological Features (PBFs) Affected	Response and Rationale of Effect	Magnitude of Effect	Weight of Evidence
Spawning Adults, Incubation of Eggs, and Rearing for Fry	Spring and Summer Operations	From Keswick Dam to Bend Bridge	River Flows for Spawning, Incubation, Fry Development and Emergence, and Downstream Transport of Juveniles	Increased Spring flows can provide adult holding habitat; however, excessive summer flows could negatively impact the aquatic food web by reducing essential prey and promoting less nutritious species.	Medium	High

Life Stage	Action Component	Location of Effect	Physical and Biological Features (PBFs) Affected	Response and Rationale of Effect	Magnitude of Effect	Weight of Evidence
Spawning Adults, Incubation of Eggs, and Rearing for Fry	Spring and Summer Operations	From Keswick Dam to Bend Bridge	Clean Gravel for Spawning Substrate	The lack of sufficient natural flows prevents the movement of gravel and sediment, leading to the formation of an "armored" riverbed dominated by cobbles with poor transport of augmented gravel in drier years.	Low	Medium
Spawning Adults, Incubation of Eggs, and Rearing for Fry	Spring and Summer Operations	From Keswick Dam to Bend Bridge	Predicted mean proportional 80th percentile TDM estimate	Exceedance of water temperature objectives at CCR compliance point, particularly during dry and critical years, degrades adult holding, egg incubation, and juvenile rearing habitat	High	High
Freshwater Rearing Habitat for Juveniles	Fall and Winter Operations	From Keswick Dam to the Delta	Habitat and Adequate Prey that are not Contaminated Riparian Habitat for Juvenile Development and Survival	Storing water in Shasta Reservoir during the winter reduces the natural flow of the river, limiting habitat and food sources for fish, especially by preventing access to floodplains. Additionally, after artificially high flows in mid-summer, water levels drop rapidly in the fall, leaving fish eggs stranded and exposed.	Medium	High

Life Stage	Action Component	Location of Effect	Physical and Biological Features (PBFs) Affected	Response and Rationale of Effect	Magnitude of Effect	Weight of Evidence
Freshwater Migratory Corridor PBFs for Out-migrating Juveniles and Spawning Adults	Fall and Winter Operations	From Keswick Dam to the Delta	Access Downstream for Juvenile Migration to San Francisco Bay and the Pacific Ocean. Access from the Pacific Ocean to Appropriate Spawning Areas	Fall and Winter flows are generally adequate to support juvenile out-migration and adult returns	Low	High
PBFs for Out-migrating Juveniles and Spawning Adults	Spring and Summer Operations	From Keswick Dam to the Delta	River Flows for Spawning, Incubation, Fry Development and Emergence, and Downstream Transport of Juveniles	Spring flows support adult holding and spawning while late summer flows support juvenile out-migration	Medium	High

Table 49. Central Valley spring-run Chinook salmon and California Central Valley steelhead summary of effects of the action on critical habitat.

Life Stage	Action Component	Location of Effect	Physical and Biological Features (PBFs) Affected	Response and Rationale of Effect	Magnitude of Effect	Weight of Evidence
Spawning Adults, Incubation of Eggs, and Rearing for Fry	Fall and Winter Operations	From Keswick Dam to Bend Bridge	Freshwater Spawning Sites	The operations of Shasta and Keswick dams limits the recruitment of clean gravel for spawning substrate as they block the downstream transport of gravels to the accessible reach of the river.	High	High
Freshwater Rearing Habitat for Juveniles		From Keswick Dam to the Delta	Freshwater Rearing Sites	Reduced flow variability decreases rearing habitat quantity and complexity	Medium	High

Life Stage	Action Component	Location of Effect	Physical and Biological Features (PBFs) Affected	Response and Rationale of Effect	Magnitude of Effect	Weight of Evidence
Freshwater Migratory Corridor PBFs for Out-migrating Juveniles and Spawning Adults	Spring Operations		Freshwater Migration Corridors	Reduced flow variability reduces cues for juvenile emigration and adult migration and habitat during the spring.	High	Medium

Table 50. Southern Distinct Population Segment of green sturgeon summary of effects of the action on critical habitat.

Life Stage	Action Component	Location of Effect	Physical and Biological Features (PBFs) Affected	Response and Rationale of Effect	Magnitude of Effect	Weight of Evidence
Habitat for Spawning Adults, Incubation of Eggs, and Rearing for Larvae sDPS green sturgeon PBFs	Spring and Summer Operations	From Inks Creek to the Delta	Water Quality Water Flow Substrate Type or Size	The flow reductions in March through May, which artificially detain high natural flows, can be expected to limit access to food-rich floodplain habitat and reduce survival	Medium	High
Freshwater Rearing Habitat for Juveniles and Subadults sDPS green sturgeon PBFs	Summer and Fall Operations		Water Quality Water Flow Food Resources Sediment Quality Depth	Colder than optimal water temperatures may slow growth and development.	Medium	Medium
Freshwater Migratory Corridor PBFs for Out-migrating Juveniles and Spawning Adults	Year-Round Operations		Migratory Corridor Sediment Quality Depth	May influence fish travel time and migration routing	Medium	High

7.2. Clear Creek Division

7.2.1. Effects of the Action on Species in Clear Creek

The Trinity Reservoir supply and operations are closely coordinated with the Shasta Division to support water supply and hydroelectric power generation for the CVP, manage flood control, and meet minimum flow and water temperature objectives within the Trinity River, Sacramento River, and Clear Creek. The proposed action includes Trinity River water that is diverted from Lewiston Reservoir to Whiskeytown Lake through the Clear Creek Tunnel and Carr Power Plant (Figure 61). The diverted water flows into Whiskeytown Lake and is diverted either into Spring Creek Tunnel, through Spring Creek Power Plant, and into Keswick Reservoir, where it can be released into the Upper Sacramento River, or released from Whiskeytown Dam into Clear Creek.

Whiskeytown Lake has a capacity of 241,000 acre-feet and current operations build storage in the spring. It is drawn down by approximately 35,000 acre-feet from November through April to regulate runoff for winter and spring flood management. Heavy rainfall events and flood control management occasionally result in glory hole spillway discharges (uncontrolled release) into Clear Creek. Although Whiskeytown Lake is primarily used as a conveyance system for trans-basin diversions, Reclamation operates both Carr and Spring Creek power plants to generate electricity and maintain lake elevations for recreation. Hydroelectric power is also generated at the City of Redding power plant on Clear Creek immediately downstream from Whiskeytown Dam. Whiskeytown Lake also supplies domestic water to the Clear Creek Community Services District.

The volume and quality (i.e., temperature) of water moving through Lewiston and Whiskeytown lakes affect Sacramento River and Clear Creek water temperatures. There are two temperature control curtains located in Whiskeytown Lake, designed to work in tandem to reduce the mixing of cold water inflows and warm surface waters, and to enhance cold water availability to the Whiskeytown Lake outlets at Spring Creek Tunnel and Whiskeytown Dam. The Oak Bottom Temperature Control Curtain (replaced in May 2016) is located at the Carr Power Plant Tailrace, and the Spring Creek Temperature Control Curtain (replaced in 2011) is located at the Spring Creek Tunnel intake (Clear Creek Technical Team 2018). The outlet works at Whiskeytown Dam has two intakes (the upper one at 1,100 feet elevation and the lower one at 972 feet elevation) to release water into Clear Creek. Reclamation evaluates the thermal profiles of Whiskeytown Lake throughout the year, and thermal stratification typically begins around April. The outlets access different water temperature zones in the stratified reservoir and can be operated to help manage downstream temperatures and conserve the cold water pool. Reclamation proposes to continue providing temperature profile measurements for Whiskeytown Lake and Trinity Reservoir to support operational decisions for water temperature management.

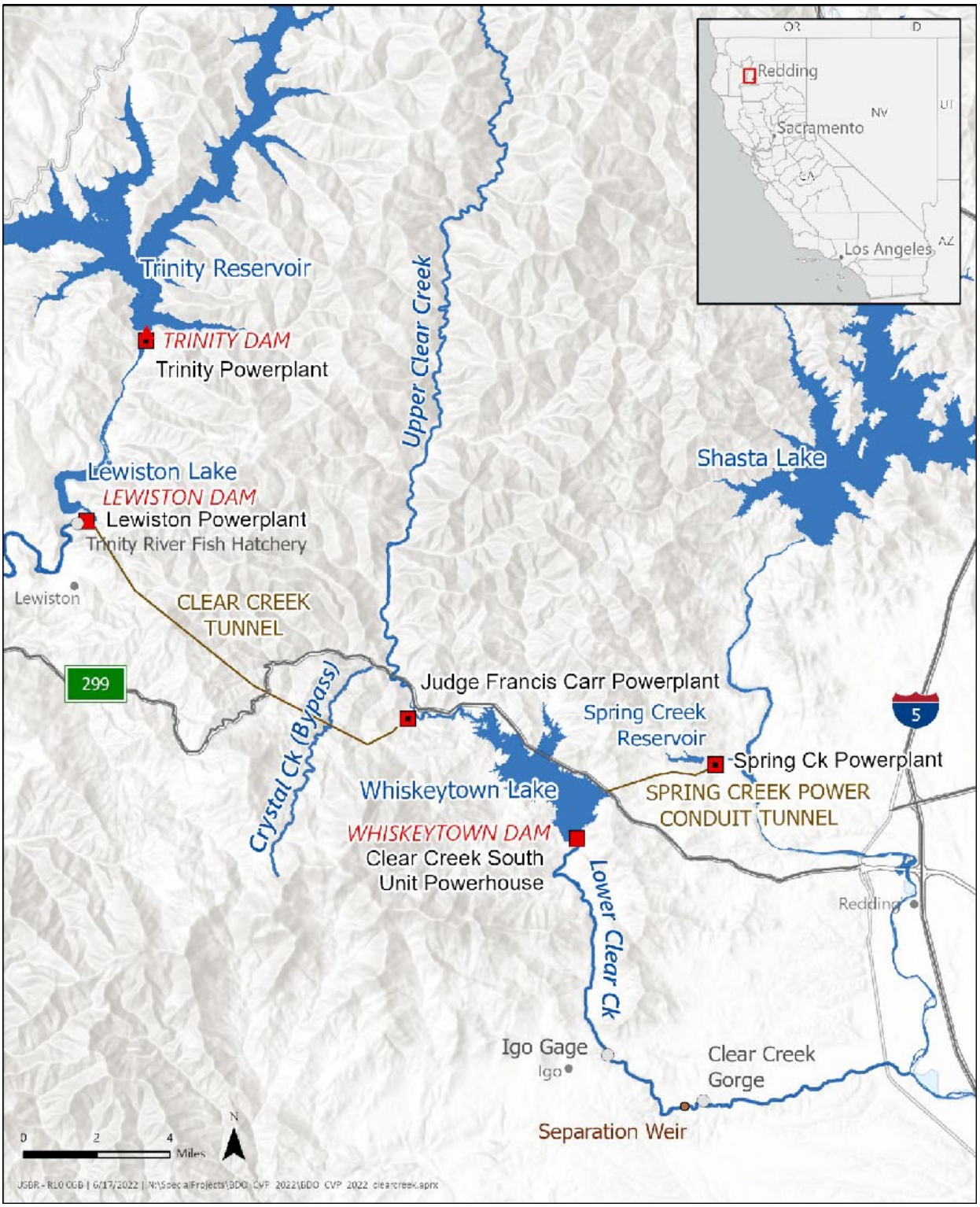


Figure 61. Clear Creek facilities in the Trinity Division of the Central Valley Project.

Source: (U.S. Bureau of Reclamation 2023-2024)

This section addresses the portion of Trinity River Division water that is diverted into Whiskeytown Lake and released into Clear Creek. Reclamation proposes to provide releases from Whiskeytown Dam into Clear Creek to meet water temperature objectives for CV spring-run and CCV steelhead, provide minimum instream flows, and create pulse flows for both attraction of adult CV spring-run and for channel maintenance. See Figure 62 for the deconstructed CVP operations in Clear Creek.

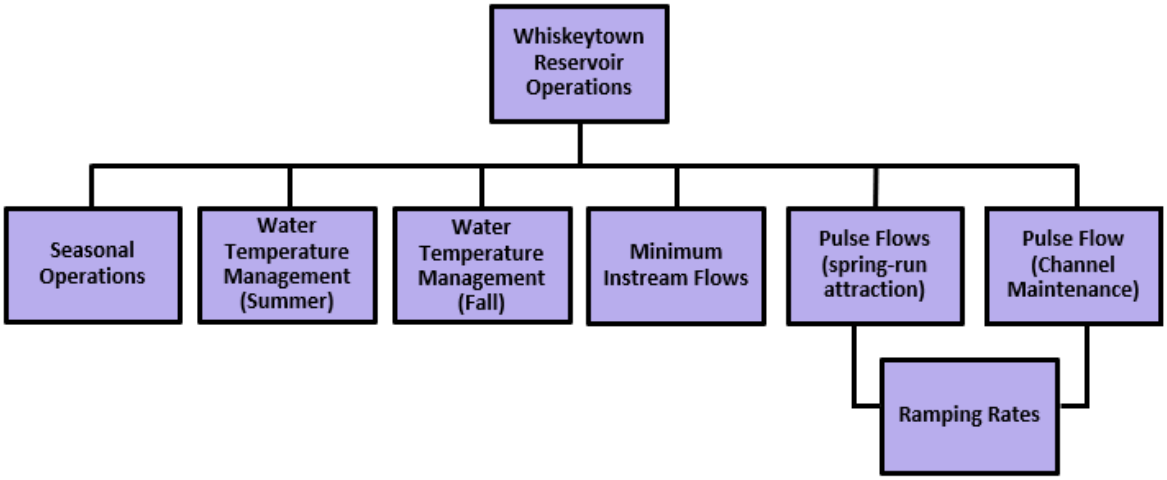


Figure 62. Deconstructed project components in Clear Creek (Trinity River Division).

NMFS deconstructed the proposed action to identify the project components that would cause stressors that may affect listed species and critical habitats (Table 51).

Table 51. Stressors affected by components of the proposed action in Clear Creek.

CLEAR CREEK COMPONENTS	Food availability	Migration cues	Pathogens & disease	Redd quality	Refuge habitat	Spawning Habitat	Strand ing	Water temperature
Seasonal Operations	X							X
Water Temperature Management (Summer)			X			X		X
Water Temperature Management (Fall)				X		X		X
Minimum Instream Flow	X	X			X	X		X

CLEAR CREEK COMPONENTS	Food availability	Migration cues	Pathogens & disease	Redd quality	Refuge habitat	Spawning Habitat	Strand ing	Water temperature
Spring Pulse Flows		X				X	X	X
Channel Maintenance Pulse Flow						X		
Ramping Rates							X	

The exposure and response to the project-related stressors are analyzed in the following sections for each proposed action component.

7.2.1.1. Seasonal Operations

As described in Section 3.5 of the BA (U.S. Bureau of Reclamation 2023-2024), Reclamation operates and maintains Whiskeytown Dam for irrigation and other beneficial uses, hydroelectric power generation, fish and wildlife, recreation, and water rights requirements.

In the winter and spring, Whiskeytown Lake is operated to regulate flows for flood management. Starting in November, Reclamation draws down Whiskeytown Lake by approximately 35,000 acre-feet to create flood management space, generally refilling in April or May. During flood conditions, imports of Trinity River water to Whiskeytown Lake may be suspended to avoid aggravating high flow conditions downstream. Heavy rainfall occasionally results in uncontrolled Whiskeytown glory hole spillway discharges to Clear Creek.

During the summer and early fall, Reclamation operations maintain lake elevations that are as full as practical for recreation. Summer and fall imports from Trinity Lake help maintain Whiskeytown Lake elevations, provide cool water for releases to Clear Creek for temperature control objectives, and decrease retention time in Lewiston Lake (minimizing temperature increases).

Clear Creek operations are largely managed by Reclamation through Governance, which includes two main coordination forums that will meet regularly to discuss seasonal and real-time operations. These include the SHOT, which is described in the Sacramento River section of this opinion. The CCTT comprises agency representatives and interested parties who will use the best available science to provide technical input to Reclamation on habitat restoration, the shaping and timing of flows released from Whiskeytown Dam to optimize biological benefits downstream, and providing recommendations on operations to meet temperature criteria. The CCTT meets quarterly, or more frequently as needed. The CCTT develops a flow schedule every year, and may adjust the schedule using recent monitoring information. For each specific seasonal action component, Reclamation will request NMFS, USFWS and CDFW to provide technical assistance along with the other members through these groups. Governance describes that the groups will strive to reach consensus; if consensus cannot be reached, group members may elevate to the next higher level for resolution. Agency directors may reserve final decision

making for matters under their respective authority.

Spring Creek Debris Dam

Reclamation operates and maintains Spring Creek Debris Dam on Spring Creek for hydroelectric power generation and Upper Sacramento River temperature control and water rights requirements. Spring Creek Debris Dam controls debris and contaminated runoff from old mine tailings on Spring Creek, which would otherwise enter the Spring Creek Power Plant tailrace. Water contaminated with heavy metals from Spring Creek Debris Dam and Spring Creek Power Plant discharge into Keswick Reservoir.

Segregation Weir

Central Valley spring-run Chinook salmon migrate into Clear Creek several months before fall-run Chinook salmon migration begins. A large portion of the Clear Creek CV spring-run population typically moves to the upper 10 miles of the creek just below Whiskeytown Dam to hold in the deeper and colder water of the canyon (Figure 63). The USFWS installs and operates a temporary segregation weir each year to physically separate the two runs during spawning to minimize hybridization and redd superimposition. The segregation weir is placed in late August, before the arrival of fall-run Chinook salmon and just prior to the onset of CV spring-run spawning. It is left in place until early November, after the peak of fall-run Chinook salmon spawning occurs.

Reclamation proposes to continue to ensure a segregation weir is installed on Clear Creek between the Gorge Cascade and Clear Creek Road Bridge in late August and remains there until early November after the peak of fall-run Chinook salmon spawning occurs. Reclamation, through the Clear Creek Technical Team (CCTT), will select the location based on channel cross-section suitability for weir placement and the distribution of adult CV spring-run Chinook salmon holding locations. Previous placements have occurred at river mile 8.2 or 7.5. An additional location for potential installation is being prepared at river mile 7.25. Any CV spring-run Chinook salmon downstream of the weir are likely to hybridize with fall-run Chinook salmon, or the redds would be subject to redd superimposition.

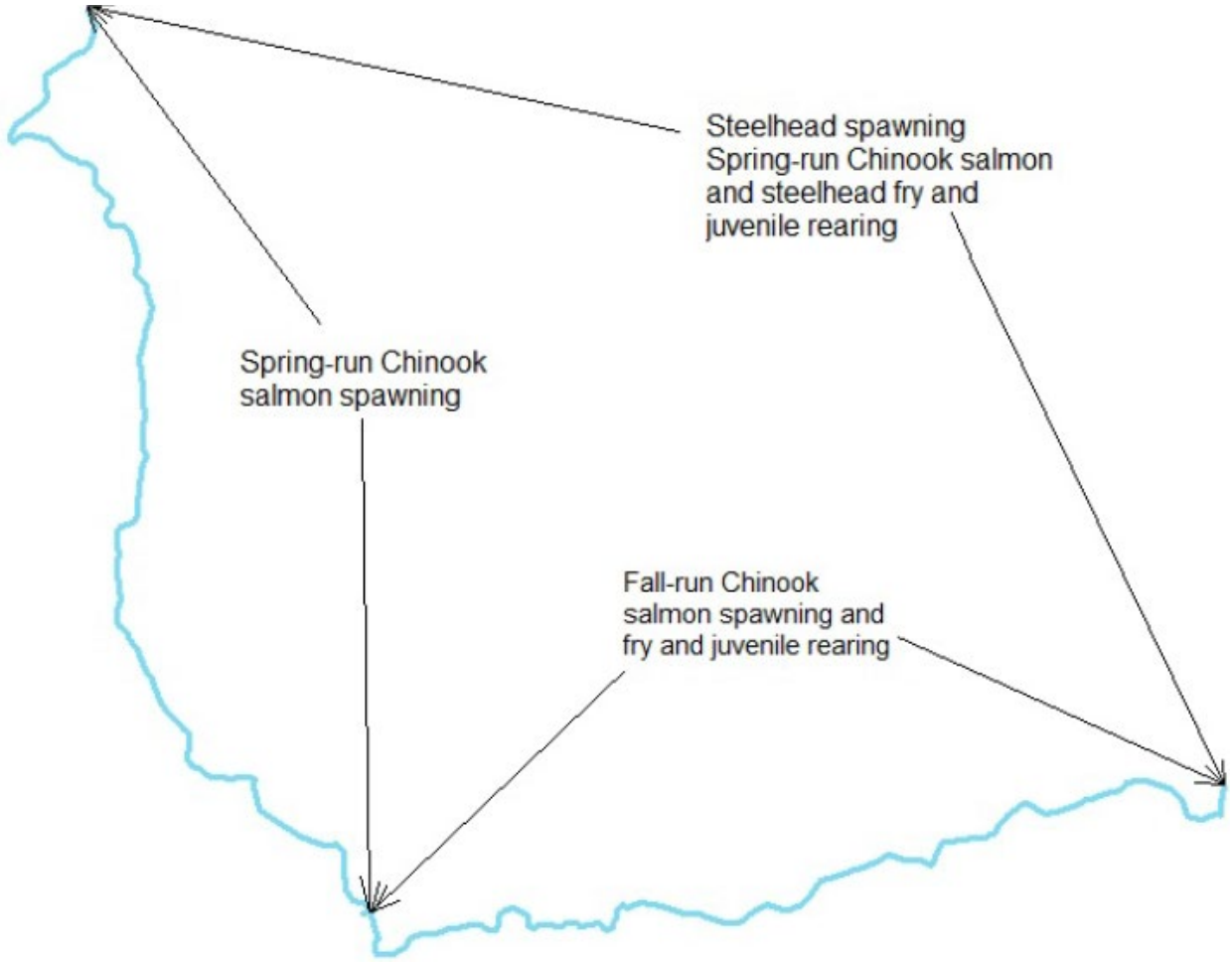


Figure 63. Spatial distribution of adult and juvenile Central Valley spring-run Chinook salmon, Central Valley fall-run Chinook salmon, and California Central Valley steelhead in Clear Creek.

Source: (U.S. Fish and Wildlife Service 2015a).

7.2.1.2. Water Temperature Management

Reclamation proposes to manage Whiskeytown Dam releases to meet the following daily average water temperatures at the USGS Igo stream gauge station:

- 61°F from June 1 through August 15
- 60°F from August 16 through September 15
- 56°F from September 16 through November 15

The proposed water temperature objectives are similar to what have been in place in Clear Creek since 1999 to reduce thermal stress to CV spring-run Chinook salmon during holding, spawning, and egg incubation, and over-summering CCV steelhead. Different from current operations is the 61°F from June 1 through August 15, rather than 60°F during the beginning of the summer holding period. During this period, water temperatures above the Igo compliance would be cooler than 60°F. During the spawning period (September 16–October 31), most CV spring-run

Chinook salmon are located upstream of the Igo compliance point. In dry, critical, or import curtailment years (based on the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification [California Department of Water Resources 2024b]), Reclamation will operate Whiskeytown Dam as close to these temperatures as practicable, but acknowledges that the temperature objectives may not be met.

The amount of cold water pool available at Trinity Reservoir depends on carry-over storage, reservoir water temperature, and the amount, timing, and water temperature of inflows from Trinity Reservoir through Whiskeytown Lake to Keswick Reservoir and Clear Creek. Since the Trinity River 2000 ROD flows were first implemented in 2005, temperature compliance of 56°F or less during the September 16 to October 31 spawning period (as discussed below) at the Igo gauge has been more difficult to meet due to changes in water diversion patterns that have resulted in longer retention time and warming in Lewiston Reservoir. By September, the cold water pool in Whiskeytown Lake becomes limited, and in some cases may result in less cold water available for Clear Creek during the CV spring-run Chinook salmon spawning period.

Figure 64 shows water temperatures at Igo are generally cool in November to May and warmer June to October.

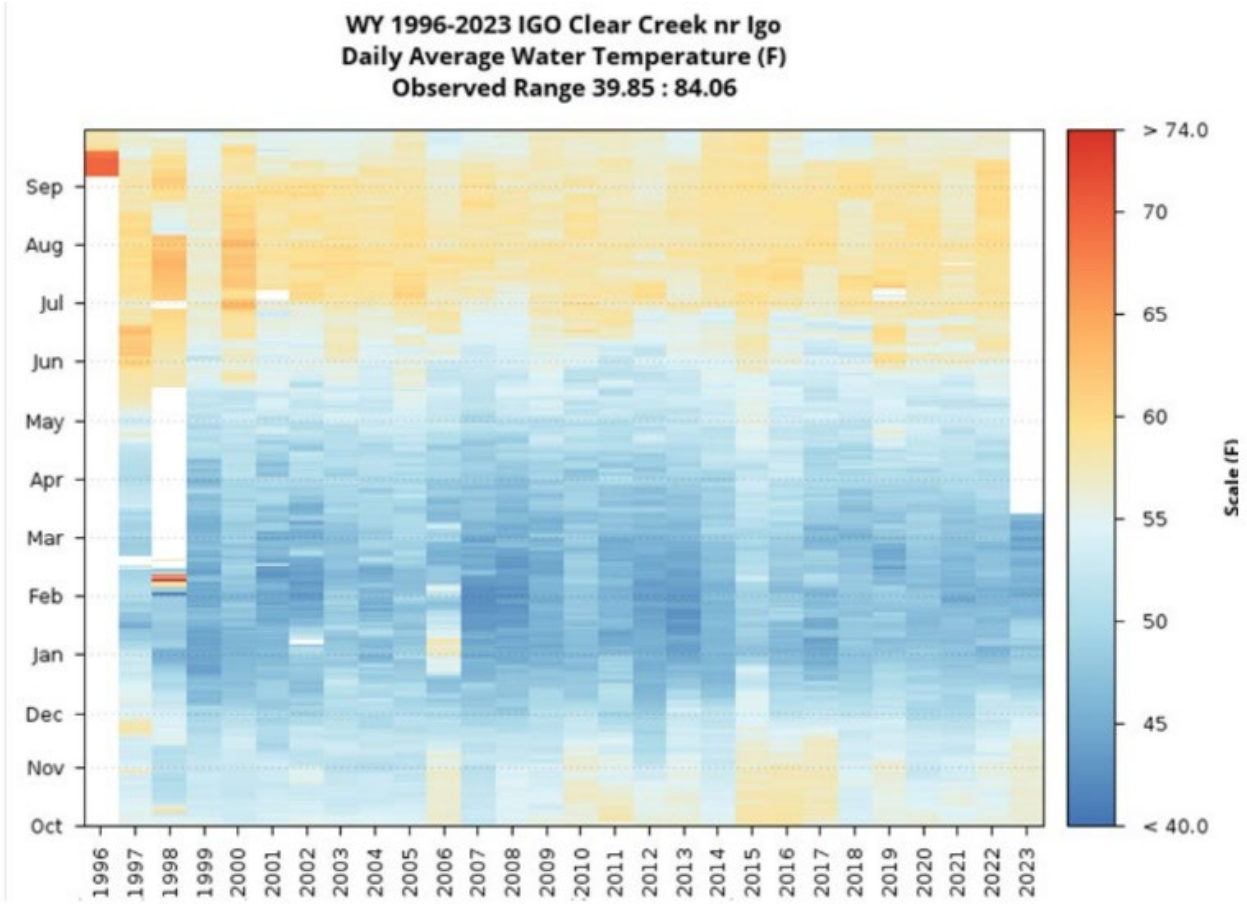


Figure 64. Clear Creek near Igo Daily Average Water Temperature (°F) for Water Year 1996–2023.

Source: (U.S. Bureau of Reclamation 2023-2024).

Additional flow releases from Whiskeytown Dam may be required to meet temperature objectives in Clear Creek. Reclamation will determine if additional water is available and inform the agency representatives through the CCTT. If 2 consecutive days of mean daily water temperature objectives are exceeded, and Reclamation determines additional water is available, then 25 cfs per day will be added to the base flow to address temperatures. Any flow changes completed for temperature management in the late summer or fall would be maintained until the base flow of the seasonal hydrograph rises to meet the elevated temperature release.

For the Clear Creek analysis, Reclamation used the HEC-5Q model to simulate temperature conditions affected by CVP and SWP operations, using CalSim 3 output for Whiskeytown Lake. Outputs were provided for three locations: Whiskeytown Dam (river mile 18), Igo temperature compliance point (river mile 11), and the confluence of Clear Creek and the Sacramento River.

7.2.1.3. Minimum Instream Flows (Seasonally Variable Hydrograph)

Reclamation proposes to provide intra-annual variation to emulate natural processes. Currently, the minimum instream base flows do not mimic the natural hydrology (see Figure 65). Under the

proposed action, flows released from Whiskeytown Dam will oscillate over a 1-year period (Figure 66). In critical water year types, Reclamation will target an average 150 cfs flow based on available water from Trinity Reservoir and attempt to maintain flows above 100 cfs.

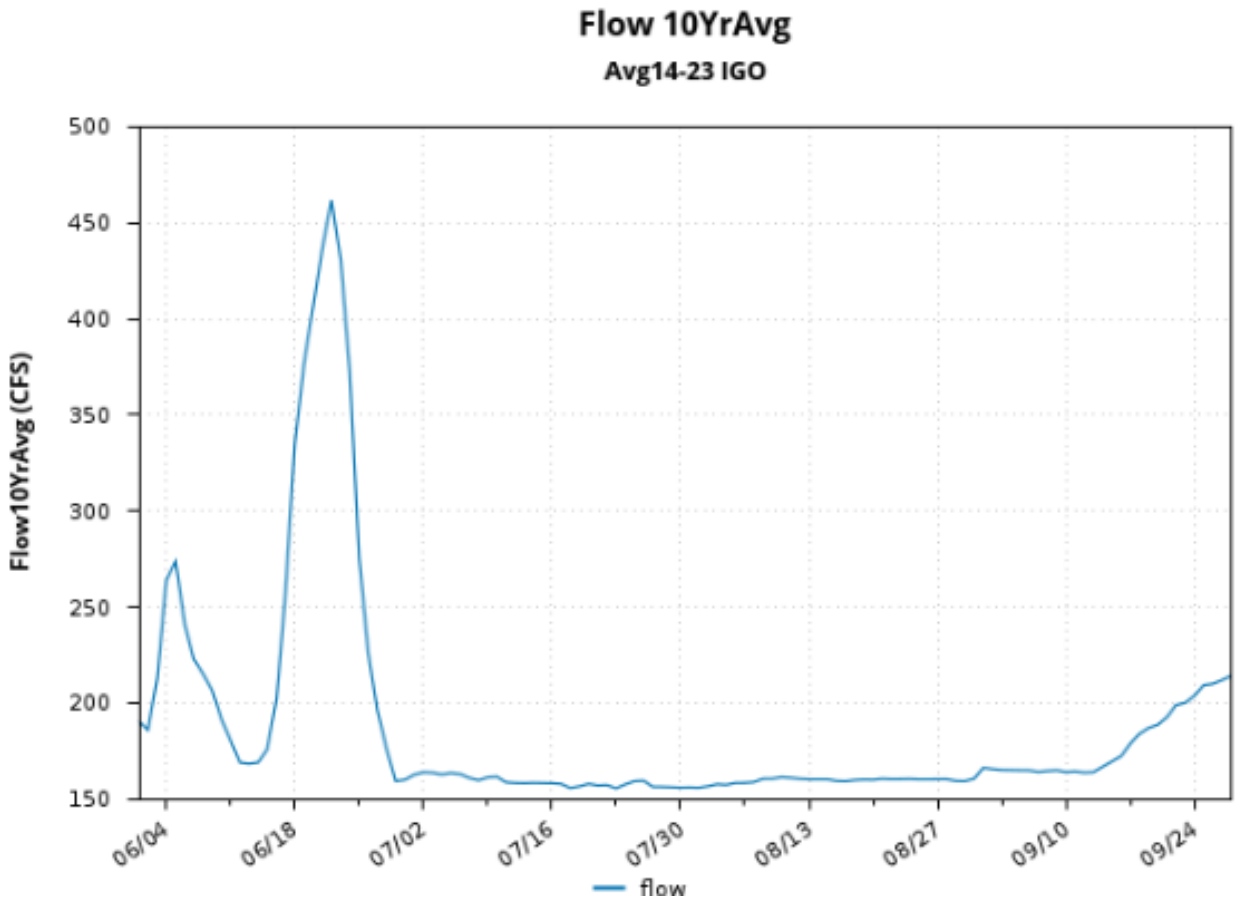


Figure 65. 10-year average flows (2014–2023) at Igo gauge in Clear Creek under current operations of 200 cubic feet per second (cfs) and 150 cfs base flows, pulse flows, and natural flows.

Source: SacPAS (University of Washington Columbia Basin Research 2024b)

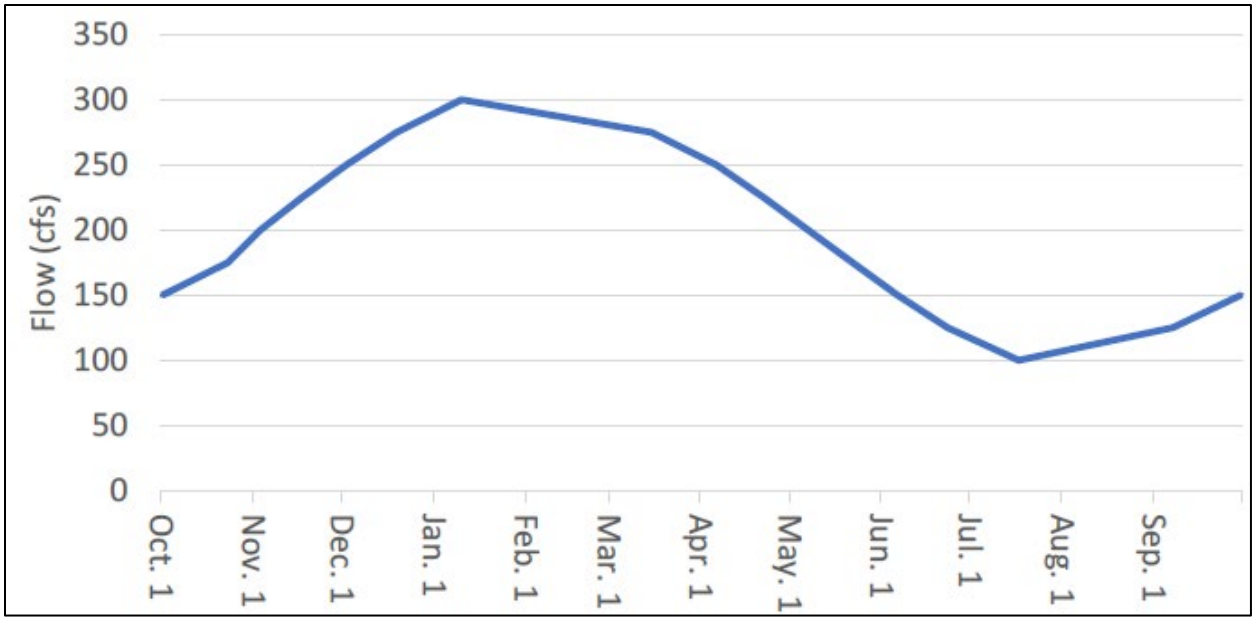


Figure 66. Clear Creek seasonally variable hydrograph minimum flows (cubic feet per second), except in critical water years.

Source: (U.S. Bureau of Reclamation 2023-2024)

Reclamation, with input from NMFS and other resource/fish agencies in the CCTT, will schedule the hydrograph to maximize multi-species benefits. Reclamation, through the CCTT, may modify the timing and flow rates by February 1 of each year and may update through May on a case-by-case basis.

7.2.1.4. Pulse Flows

Except in years with significant uncontrolled spill, Reclamation will release up to 10,000 acre-feet from Whiskeytown Dam for channel maintenance flows, spring attraction flows, and to meet other physical and biological objectives. The full pulse flow volume (10,000 acre-feet) will be available if the Sacramento Valley Index at 90-percent exceedance level is greater than 5.4 (dry or wetter years). If the Sacramento Valley Index exceedance level is equal to or less than 5.4 (critical years), Reclamation would limit releases of pulse flows to 5,000 acre-feet. Reclamation, through CCTT, will develop pulse flow schedules, which include measures (e.g., nighttime down ramping, slow down ramping rates, coinciding with natural precipitation events) to mitigate for potential risks (e.g., juvenile fish stranding). The pulse flows will be scheduled on or after February 1 and will not exceed the safe outlet works capacity of Whiskeytown Dam (currently 840 cfs).

7.2.1.5. Ramping Rates

Reclamation proposes to continue to use down ramping rates of up to 25 cfs per hour and schedule these reductions in consideration of listed species behavior. Reclamation may vary from these down ramping rates during flood control. Reclamation, through the CCTT, may develop a faster down ramping rate on a case-by-case basis.

7.2.1.6. Effects of the Action on ESA-Listed Species

7.2.1.6.1. Effects of Water Temperature Management

Reclamation proposes to manage Whiskeytown Dam releases to meet daily average water temperatures to reduce thermal stress to over-summering CCV steelhead (June 1 through September 15) and CV spring-run Chinook salmon during holding, spawning, and embryo incubation (September 16 through November 15). From June 1 through August 15, flows under the seasonal oscillating schedule are expected to range from approximately 175 cfs to 100 cfs. Reclamation is also proposing to operate to meet the 56°F temperature objective through November 15, providing a temperature management period that covers the time when CV spring-run Chinook salmon eggs are incubating and fry may be beginning to emerge.

Water temperature objectives have been in place in Clear Creek since 1999. Since then, daily average water temperatures have generally been below 60°F at Igo during the summer holding period. However, water temperatures have exceeded 56°F during the mid-September through October spawning period, and exceedance occurs more frequently in drier water year types (Figure 67).

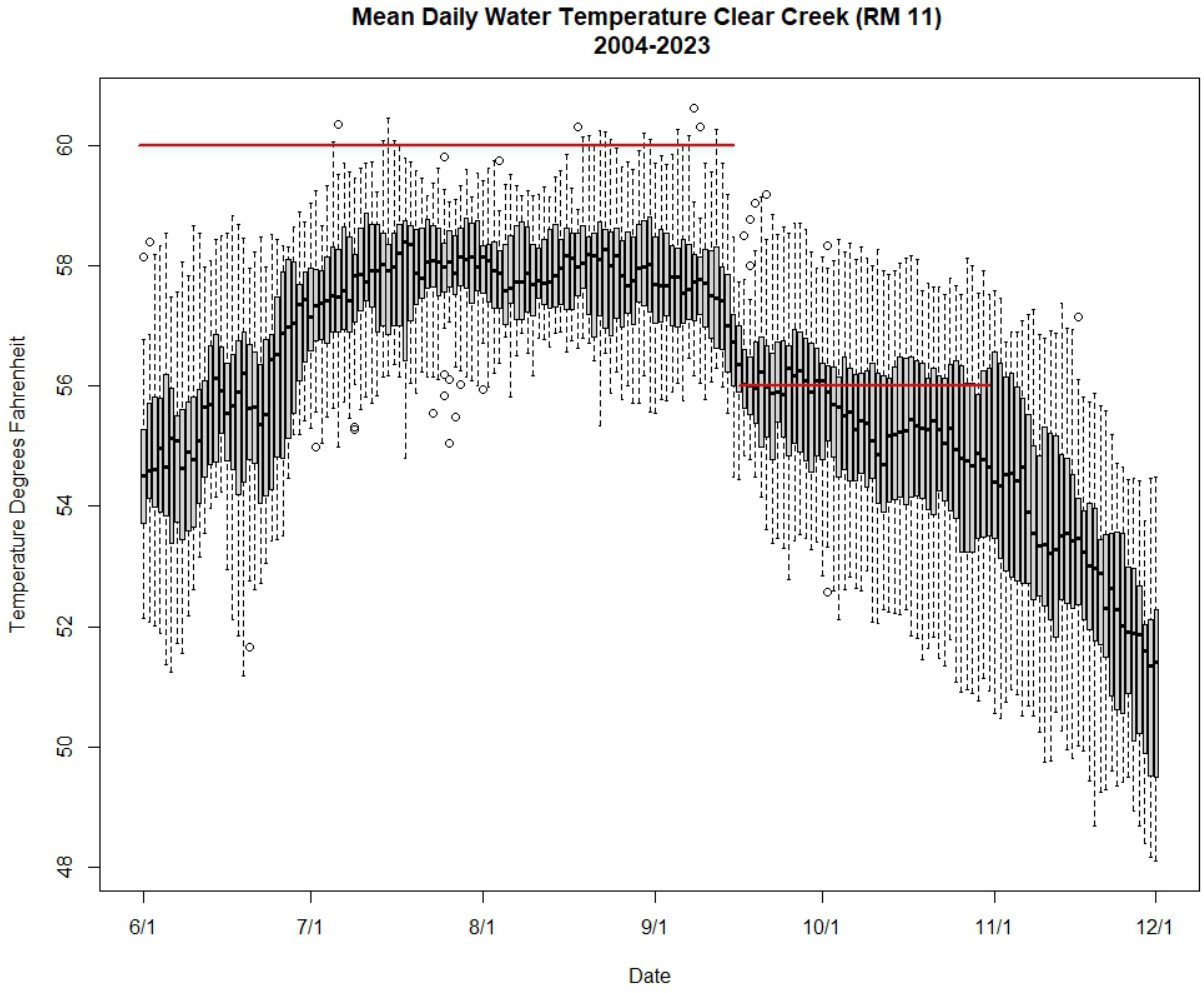


Figure 67. Historic water temperatures in Clear Creek at Igo, 2004–2023. Red lines indicate temperature objectives from the past operations.

Source: (U.S. Fish and Wildlife Service 2024)

Historic water temperatures near the mouth of Clear Creek are typically the warmest in July and August, with the mean daily water temperature often reaching the upper 60s (°F). June mean daily water temperatures are generally in the lower 60s (Figure 68).

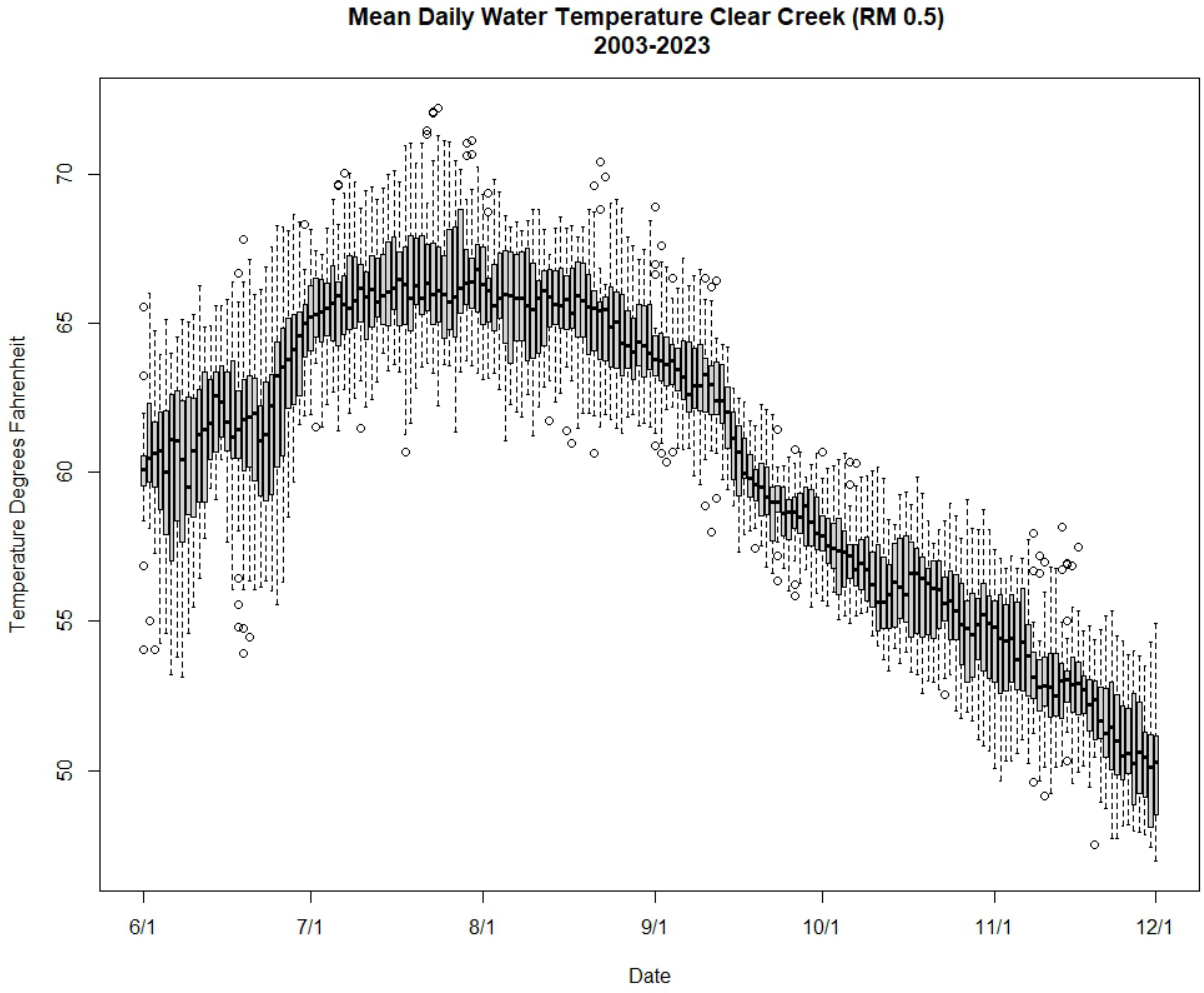


Figure 68. Historic water temperatures in Clear Creek just above the confluence with Sacramento River, 2003–2023.

Source: (U.S. Fish and Wildlife Service 2024).

Over the last 13 years, the 60°F temperature objective has been met in most years, while the 56°F temperature objective has been more difficult to meet, particularly in critically dry years (Figure 67 and Table 52).

Table 52. Proportion of days that water temperatures at Clear Creek IGO gauge met the objectives during calendar years 2011–2023.

Water Year Type	Calendar Year	Holding Temperature ≤ 60°F June 1–September 15	Spawning Temperature ≤ 56°F September 16–October 31
Wet	2011	100% (107 of 107 days)	63% (29 of 46 days)
Below Normal	2012	100% (107 of 107 days)	65% (30 of 46 days)
Dry	2013	100% (107 of 107 days)	98% (45 of 46 days)
Critical	2014	100% (107 of 107 days)	0% (0 of 46 days)
Critical	2015	100% (107 of 107 days)	0% (0 of 46 days)
Below Normal	2016	98% (105 of 107 days)	15% (7 of 46 days)
Wet	2017	100% (107 of 107 days)	100% (46 of 46 days)
Below Normal	2018	99% (106 of 107 days)	91% (42 of 46 days)
Wet	2019	99% (97 of 98 days)	67% (31 of 46 days)
Dry	2020	99% (103 of 104 days)	72% (33 of 46 days)
Critical	2021	100% (105 of 105 days)	80% (37 of 46 days)
Critical	2022	93% (100 of 107 days)	15% (7 of 46 days)
Wet	2023	100% (107 of 107 days)	98% (45 of 46 days)

Source: (Clear Creek Technical Team 2023).

The current June 1 to September 15 60°F objective has been met 99 percent of the past 13 years on average, while the September 16 to October 31 56°F objective has been met 59 percent of the time over this same period. It is more difficult to achieve the 56°F temperature objective during critical years, as shown in Table 52. Past operations indicate that average monthly summer base flows in July and August have ranged between 50 cfs and 180 cfs. Base flows greater than 150 cfs have been released in critical water year types under current operations to meet the water temperature objective in the summer, and may be needed to meet the temperature objectives of the proposed action. Reduced flows in the summer will help maintain the cold water pool in Whiskeytown Lake, allowing for higher releases in the winter and spring, which is expected to result in cooler water temperatures.

7.2.1.6.1.1. Central Valley Spring-Run Chinook Salmon Exposure and Response

7.2.1.6.1.1.1. Exposure (Life Stage Location and Timing)

Adult CV spring-run Chinook salmon migrate into Clear Creek from April to July, and peak passage occurs in May and June (Clear Creek Technical Team 2023). The adults distribute throughout Clear Creek and hold in deep pools throughout the summer from Whiskeytown Dam (river mile 18.3) as far downstream as river mile 4. Spawning mostly occurs in the upper alluvial and canyon reaches (U.S. Fish and Wildlife Service 2015a) from early September through October, and peaks in late-September (Giovannetti and Brown 2013). Egg incubation occurs primarily from September to October.

Based on juvenile passage indices from the USFWS rotary screw trap (river mile 8.4), fry emergence occurs from the end of October through January, peaking in December. A small number of juveniles and smolts are captured throughout the remainder of the monitoring season, which generally ends on July 1 annually (Earley et al. 2009, Schraml et al. 2018, U.S. Fish and Wildlife Service 2024). While the majority of juvenile CV spring-run Chinook salmon out-migrate as fry, a portion rears in Clear Creek through the spring and summer and emigrate as sub-yearlings. Juvenile CV spring-run Chinook salmon have been observed during snorkel surveys in the spring and summer months (U.S. Fish and Wildlife Service 2007).

The water temperature management season, therefore, encompasses the CV spring-run Chinook salmon adult holding, spawning, and egg incubation/alevin development life stages, and ends at the beginning of fry emergence. Most CV spring-run Chinook salmon are expected to be exposed to these resulting temperatures during those life stages. A small number of sub-yearling juveniles are expected to be present during the temperature management season.

7.2.1.6.1.1.2. Response

At the mouth of Clear Creek, water temperatures greater than 68°F from June through August create a passage impediment, lowering adult returns. Adult CV spring-run Chinook salmon migration into Clear Creek continues through the temperature management period, with approximately 35 percent of the population index passing in June, and very low numbers passing in July and August. Daily average water temperatures near the mouth of Clear Creek are generally within optimal ranges for adult migration in June, suboptimal (greater than 68ºF) primarily in July and August, and occasionally over 70ºF (when migration generally stops) in July. The low rate of migration in July and August is likely due to life history characteristics of CV spring-run Chinook salmon in the Upper Sacramento River tributaries, and temperature-related migration barriers associated with warmer water at the confluence of Clear Creek. Temperature and low flow barriers at riffles and cascades may inhibit access to the upper watershed in the summer.

Studies on the relationship of flow and water temperature on CV spring-run Chinook salmon egg-to-fry survival in Clear Creek showed that lower water temperatures lead to improved survival (Provins 2018). In developing a framework for incorporating water temperatures into recommended flow regimes, the authors, (He and Marcinkevage 2016) found that reduced numbers of adult and juvenile CV spring-run Chinook salmon in Clear Creek were associated with higher water temperatures that occurred during migration, spawning, and rearing periods.

Literature suggests that a daily average water temperature of 56°F is suboptimal for Chinook salmon egg incubation (EPA 2003, Myrick and Cech 2004, Martin et al. 2017). Reclamation's proposed change in minimum instream flows includes decreasing flows in summer and increasing flows in winter/spring. This is expected to improve the availability of cold water in Whiskeytown Reservoir, which could help meet the 56°F water temperature objective from mid-September to mid-November. However, this threshold may still be difficult to meet during critical years.

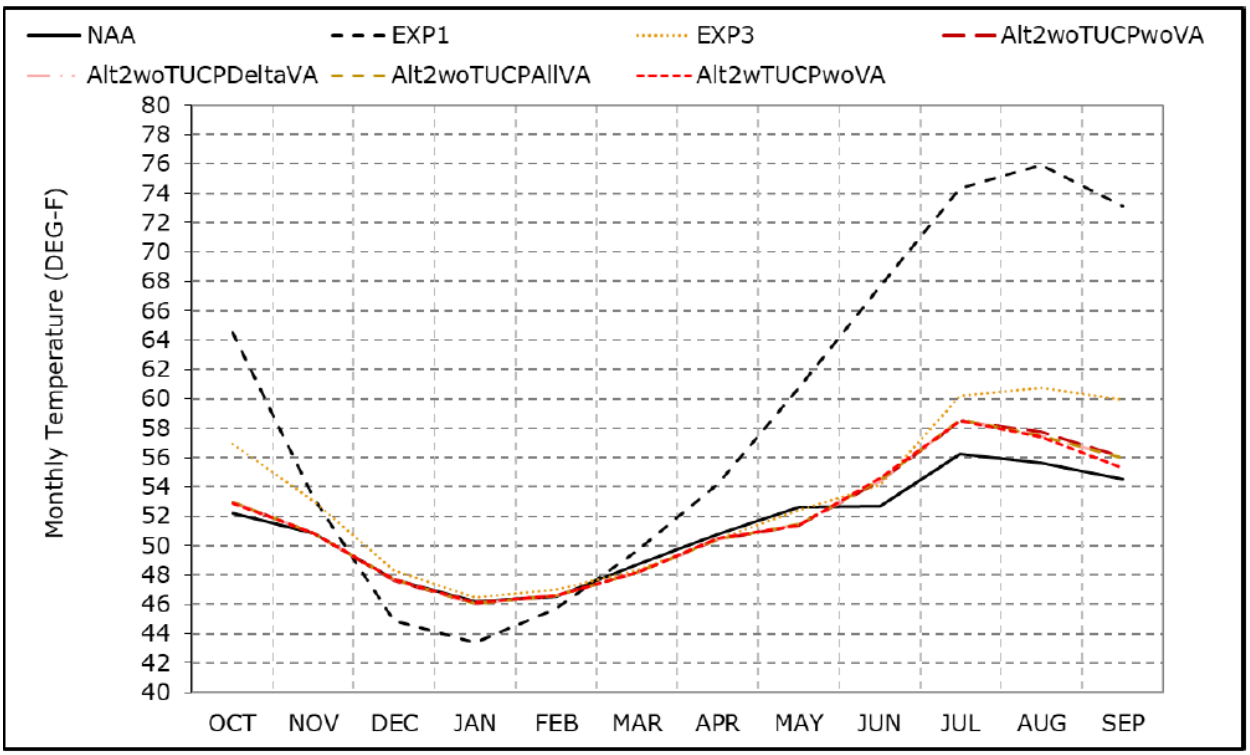
To evaluate thermal conditions for adult and juvenile salmonids in Clear Creek, exceedance plots from HEC-5Q modeling results of year-round and monthly mean water temperatures were examined with consideration of the temperature objectives under various water year types (see Figure 69, Figure 70, Figure 71, Figure 72, Figure 73, Figure 74, and Figure 75).

Although the BA modeled six operational scenarios, the Clear Creek effects analysis focused on the proposed action without TUCPs and without VAs (Alt2v1). The Alt2v2 scenario, which is a 2-year volumetric export reduction per the Delta VAs, was not used in this effects analysis since the Alt2v2 modeling results are virtually indistinguishable outside of the Delta, and did not show substantial differences in flow and temperature for Clear Creek (see Figure 69, Figure 70, Figure 71, Figure 72, Figure 73, Figure 74, and Figure 75).

The effects of the proposed action, Alt2v1, is commonly referred to as Alt2woTUCPwoVA in the model results. Other modeling results are provided in Reclamation's figures below. EXP3 modeling results illustrate how Reclamation's discretion is exercised to influence the direction of stressors. The NAA modeling scenario best represents current operations, and can be used to see how current operations differ from the proposed action.

HEC-5Q modeling results from Appendix F Modeling Results Section 1-1 (U.S. Bureau of Reclamation 2023-2024) showed that average water temperatures at the confluence of Clear Creek and the Sacramento River remain below 60°F each month under the proposed action (Alt2v1 or Alt2woTUCPwoVA, Figure 69).

Figure F.2.11-4-1. Clear Creek at Mouth, Long-Term Average Temperature



*As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).
*These results are displayed with calendar year - year type sorting.
*All scenarios are simulated at 2022 Median climate condition and 15 cm sea level rise.

Figure 69. HEC-5Q monthly modeled water temperatures at the confluence during all scenarios. The proposed action is represented by Alt2woTUCPwoVA (Alt2v1), NAA represents current operations, and EXP3 represents the obligated releases scenario.

Source: Appendix F: Modeling in (U.S. Bureau of Reclamation 2023-2024)

The HEC-5Q monthly water temperature modeling results in Appendix L_Attachment L, and in Appendix F of the BA (U.S. Bureau of Reclamation 2023-2024) during the water temperature management period (61°F at Igo from June 1 to August 15, 60°F from August 16 to September 15, and 56°F from September 16 to November 15) show the probability that the proposed action (Alt2v1) is likely to exceed the proposed water temperature objectives.

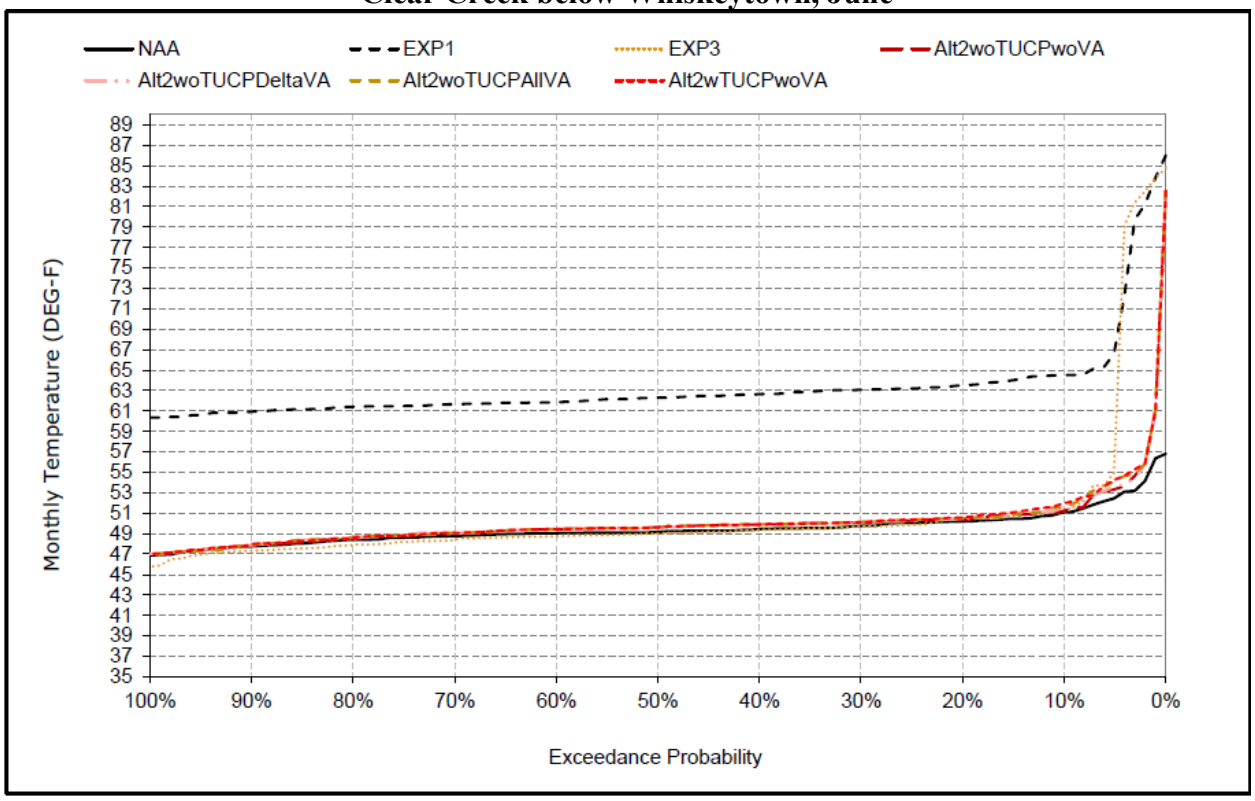


Figure 70. Exceedance plot of modeled water temperatures in Clear Creek in June. The proposed action is represented by Alt2woTUCPwoVA (Alt2v1).

Source: Figure F.2.11-2-15, Appendix F (U.S. Bureau of Reclamation 2023-2024)

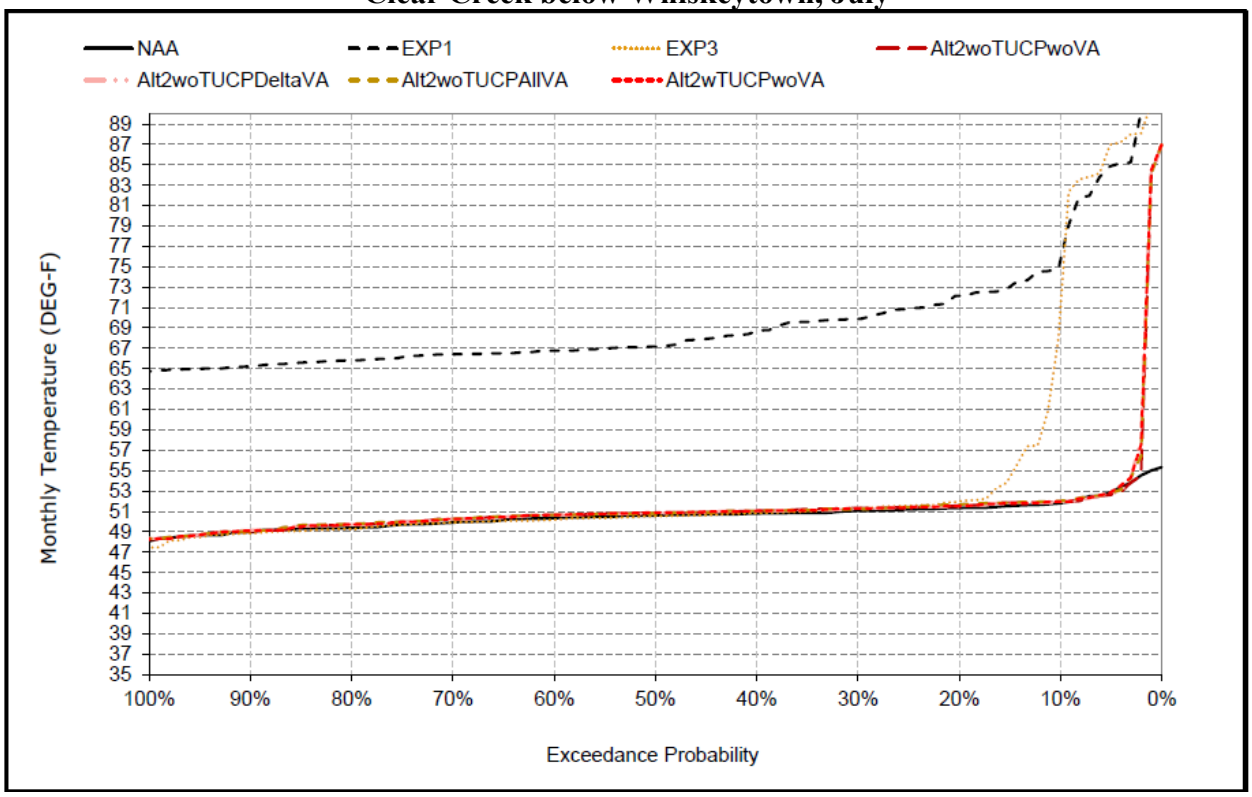


Figure 71. Exceedance plot of modeled water temperatures in Clear Creek in July. The proposed action is represented by Alt2woTUCPwoVA (Alt2v1).

Source: Figure F.2.11-2-16, Appendix F (U.S. Bureau of Reclamation 2023-2024)

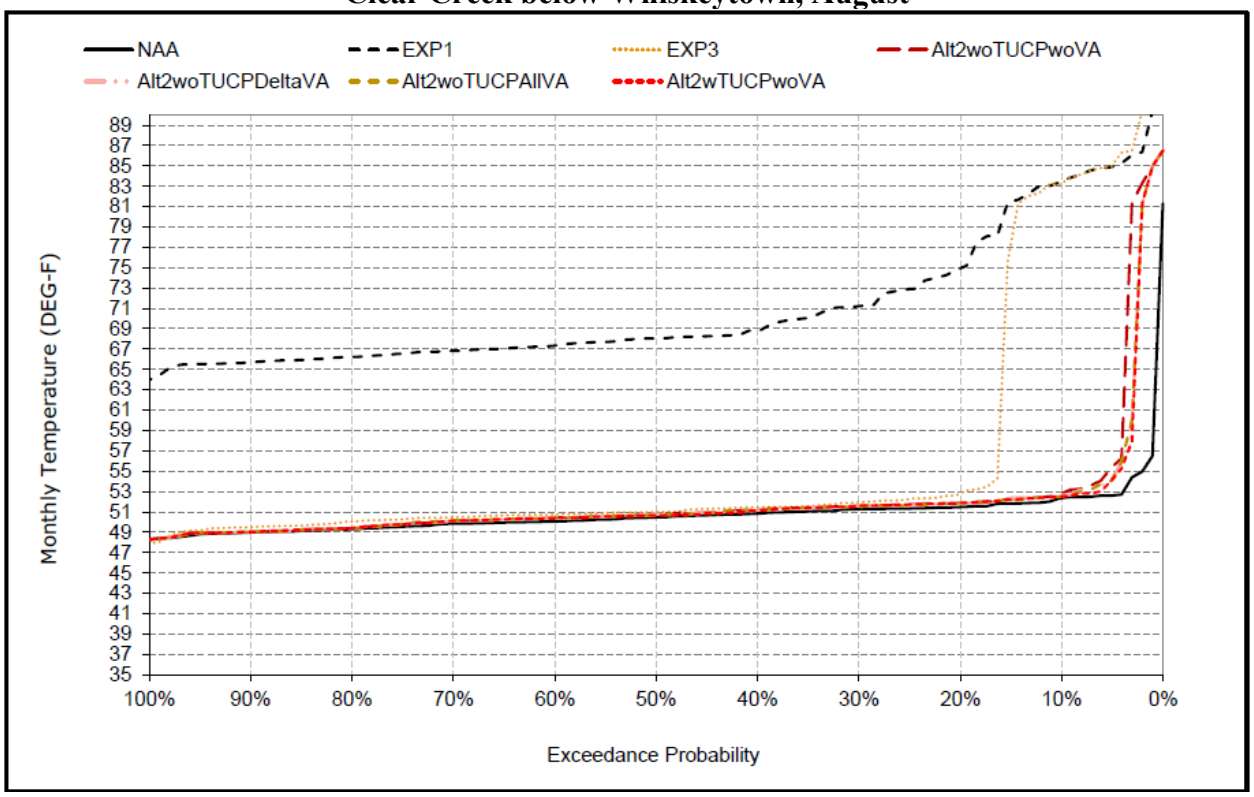


Figure 72. Exceedance plot of modeled water temperatures in Clear Creek in August. The proposed action is represented by Alt2woTUCPwoVA (Alt2v1).

Source: Figure F.2.11-2-17, Appendix F (U.S. Bureau of Reclamation 2023-2024)

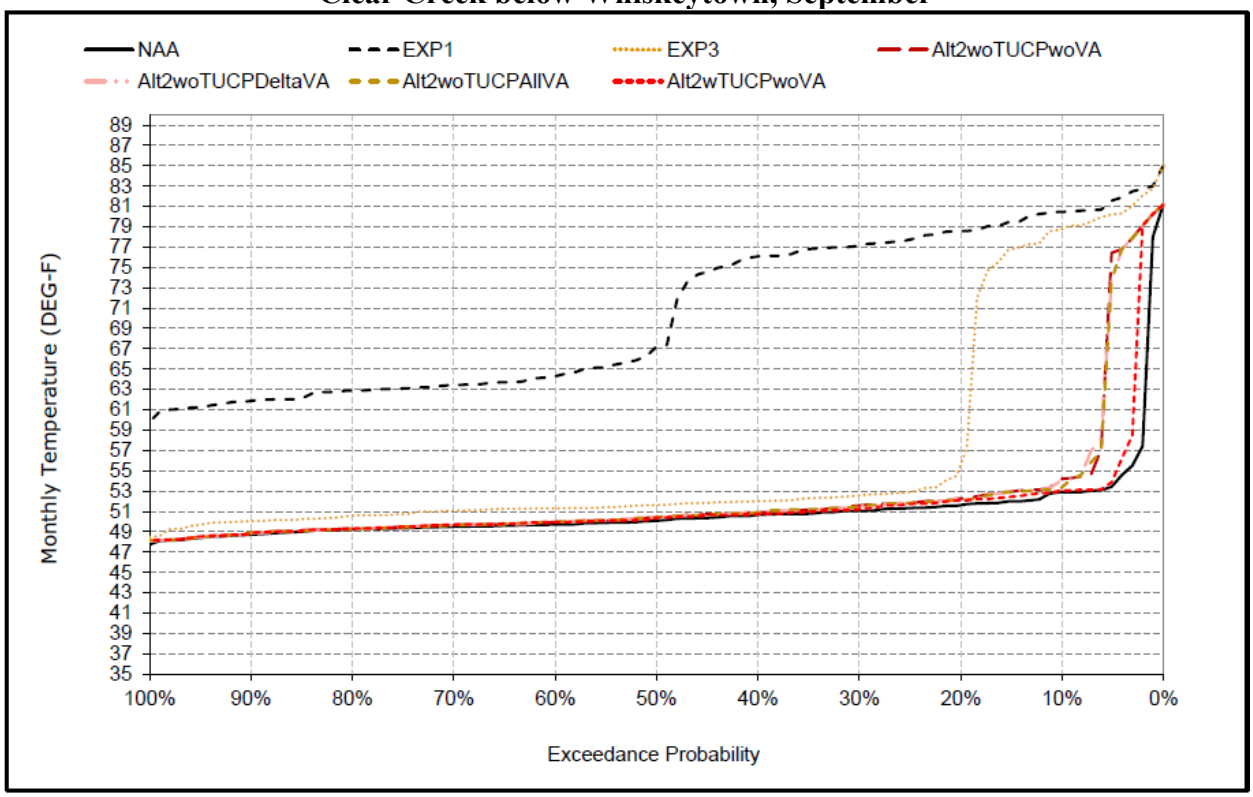


Figure 73. Exceedance plot of modeled water temperatures in Clear Creek in September. The proposed action is represented by Alt2woTUCPwoVA (Alt2v1).

Source: Figure F.2.11-2-18, Appendix F (U.S. Bureau of Reclamation 2023-2024)

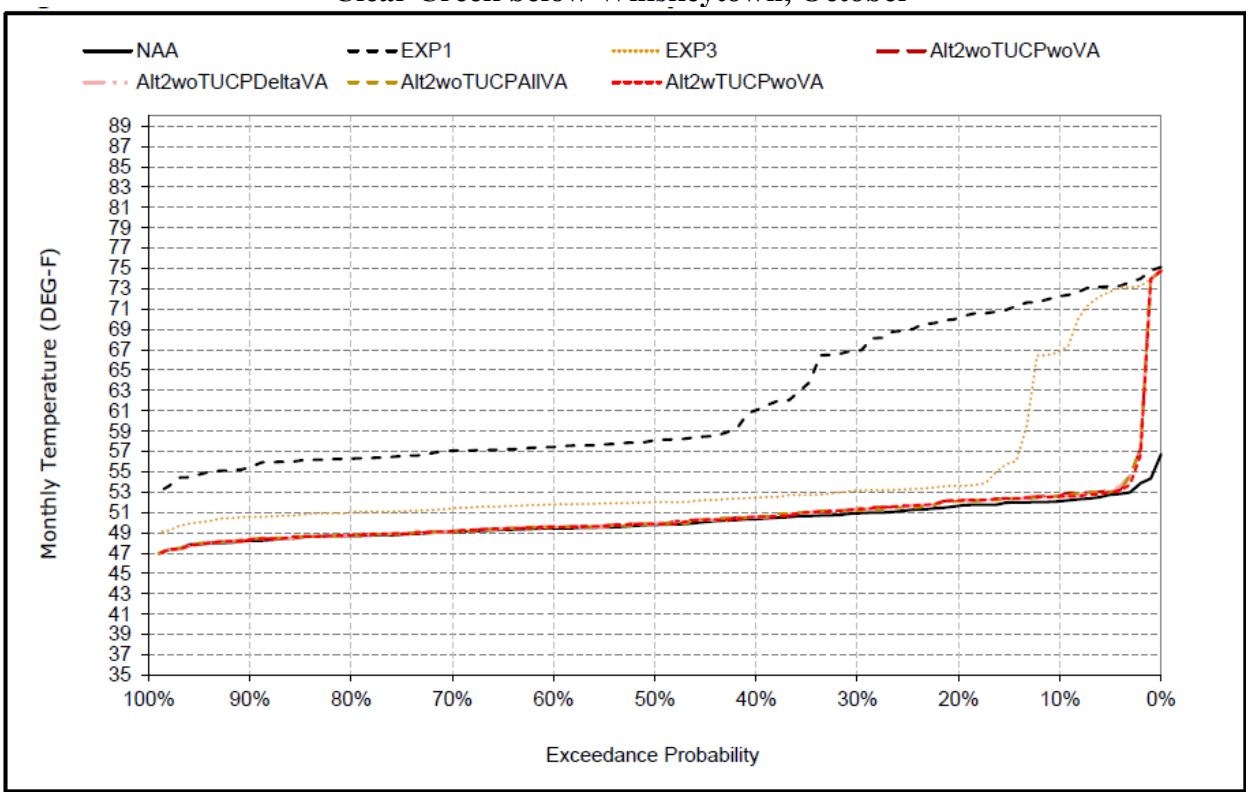


Figure 74. Exceedance plot of modeled water temperatures in Clear Creek in October. The proposed action is represented by Alt2woTUCPwoVA (Alt2v1).

Source: F.2.11-2-7, Appendix F (U.S. Bureau of Reclamation 2023-2024)

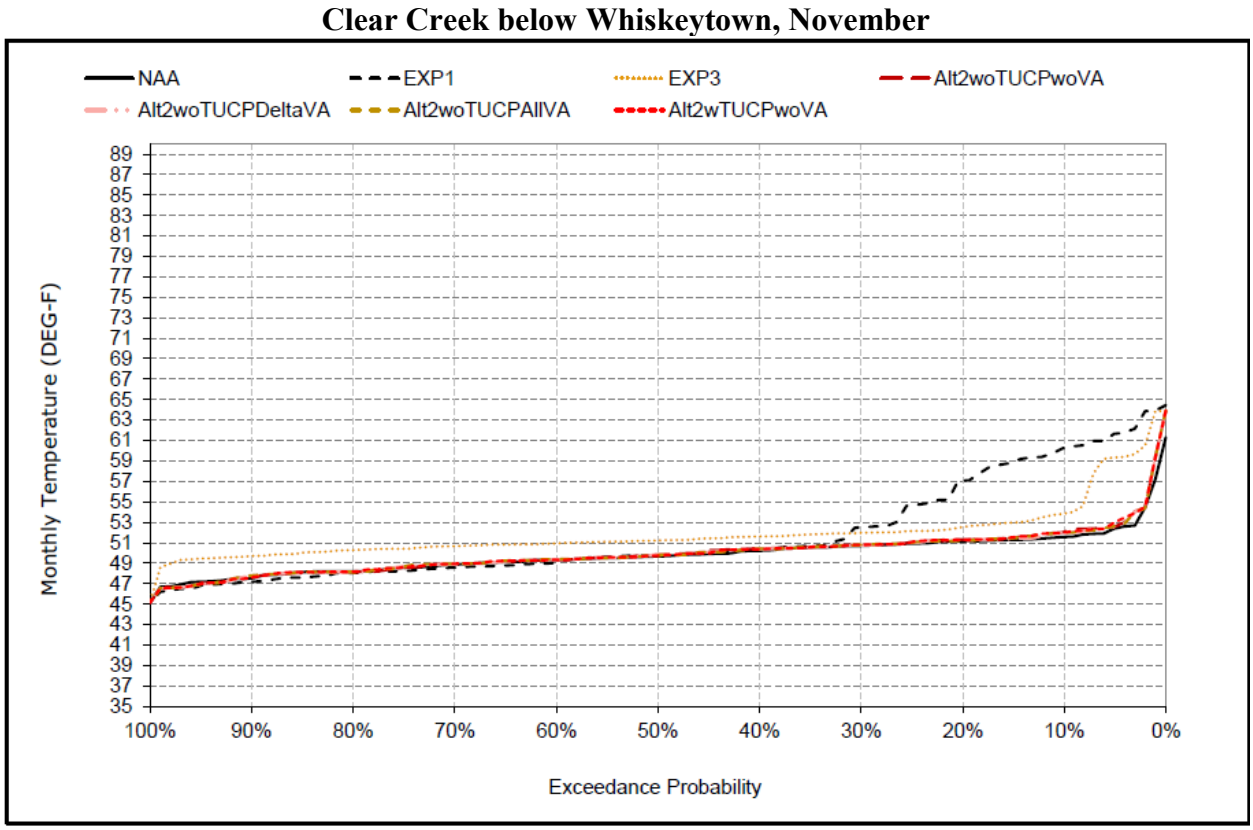


Figure 75. Exceedance plot of modeled water temperatures in Clear Creek in June. The proposed action is represented by Alt2woTUCPwoVA (Alt2v1).

Source: Figure F.2.11-2-8 (U.S. Bureau of Reclamation 2023-2024)

The monthly exceedance plots show the probability of exceedance under the proposed action and other modeling scenarios during the water temperature management season. While monthly exceedance plots are useful for assessing the conditions that the proposed action component will provide monthly, they do not reflect the daily water temperature that occurs. In addition, because the temperature objective changes on August 16 (from 61°F to 60°F) and September 16 (from 60°F to 56°F), it is difficult to compare monthly temperatures to the different objective periods. However, given this information, it is reasonable to expect that the 56°F temperature objective in mid-September will continue to be difficult to meet due to seasonally warm air temperatures this time of year.

The HEC-5Q modeling results from the BA Appendix F Modeling Results Section 1-1 (U.S. Bureau of Reclamation 2023-2024) show that water temperature objectives are expected to be met at the Igo compliance location each month under the proposed action (Alt2v1, Table 53), except in critical water year types, which are expected to occur in 16 percent of years. Monthly modeling results do not provide maximum daily average water temperatures, so there is uncertainty in how often the daily water temperature objective is expected to be exceeded. Overall, the percentage of months outside of the optimal temperature range was similar for all water year types, except for during critical water years, which are expected to result in warmer

water temperatures at Igo. During critical water years, the anticipated monthly average water temperature for September is 61°F. The temperature objective is 60°F through September 15 and 56°F starting September 16. Therefore, it is difficult to determine whether the daily average of 56°F will be met. These modeling results are similar to what was provided during the 2019 LTO consultation (Table 37 in National Marine Fisheries Service 2019b), therefore, based on past observations and future modeling predictions, we assume the 56°F temperature objective may continue to be exceeded, particularly in critical water years.

Table 53. HEC-5Q monthly modeling results at the Igo temperature gauge compliance point under Alt2v1.

Source: Figure F.2.11-2-1b, Appendix F: Modeling in (U.S. Bureau of Reclamation 2023-2024)

Statistic	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
10% Exceedance	53	52	49	47	47	48	49	50	51	52	53	54
20% Exceedance	52	51	48	46	46	47	49	49	50	52	52	52
30% Exceedance	51	51	48	46	46	47	48	49	50	51	52	52
40% Exceedance	50.5	50.4	47.4	45.6	45.8	46.6	48.1	48.5	49.9	51.1	51.2	50.9
50% Exceedance	49.9	49.8	47.0	45.3	45.3	46.3	47.8	48.2	49.6	50.9	50.8	50.4
60% Exceedance	49.6	49.3	46.8	45.0	45.2	46.1	47.5	48.0	49.4	50.7	50.4	49.9
70% Exceedance	49.2	48.9	46.5	44.7	44.7	45.8	47.1	47.7	19.1	50.3	50.1	49.7
80% Exceedance	48.7	48.1	46.3	44.6	44.6	45.3	46.7	47.3	48.5	49.7	49.4	49.3
90% Exceedance	48.4	47.7	45.8	44.3	44.1	45.0	46.5	46.7	47.9	49.1	49.0	48.
Full Simulation Period Average	51	50	47	45	45	46	48	48	50	51	52	52
Wet Water Years (28%)	49	48	47	45	45	46	47	48	50	50	50	50
Above Normal Years (14%)	49	49	47	45	45	46	47	48	50	50	50	49
Below Normal Years (18%)	50	50	48	45	45	46	48	48	49	51	51	63
Dry Years (24%)	51	51	48	46	46	47	48	48	50	51	51	51
Critical (16%)	56	53	48	46	47	48	49	50	53	56	60	60

Ongoing spawning gravel injections are not part of the proposed action; however; past spawning gravel injections have created suitable spawning habitat throughout Clear Creek, including downstream of Igo, and a large portion of redds are located here each spawning season. Incubating eggs are exposed to different water temperatures depending on redd location. In general, the redds located further upstream experience colder water temperatures in Clear Creek, especially during the earliest stages of incubation. Still, the redds may be exposed to warm water temperatures and could experience impacts from thermal stress.

Cumulative exposure to stressful water temperatures can lead to increased risk of disease, decreased fecundity, prespawn mortality, and decreased reproductive success in adult CV spring-run Chinook salmon. However, since daily average water temperatures are likely to remain below 61°F upstream of the Igo compliance point under the proposed action, adults will have access to suitable holding habitat during the summer water temperature management period. The current adult CV spring-run Chinook salmon holding distribution will likely continue under the proposed action. However, during critical water year types (16 percent of years), the 56°F water temperature objective is likely to be exceeded in September and October according to the historical record.

Under the proposed action, water temperatures upstream of Igo and for approximately 8 miles downstream would likely be within optimal ranges for juvenile rearing. Any juveniles rearing in the furthest downstream 3 miles of Clear Creek during the water temperature management period would likely be exposed to suboptimal temperatures for rearing (greater than 65°F), increasing their susceptibility to stress, disease, predation, and mortality. A small proportion of juveniles rearing and out-migrating within the lower 3 miles of Clear Creek during the summer months are expected to continue to be exposed to suboptimal conditions from water temperature management under the proposed action.

7.2.1.6.1.1.3. Summary of Effects (Proportion of Population and/or Frequency/Likelihood of Occurrence)

Adult migration into Clear Creek peaks in May and June. Water temperatures just above the confluence are typically in the lower 60s (°F) in June, and daily average water temperatures at Igo historically have not exceeded the temperature objective in June. The proposed 61°F temperature objective at Igo from June 1 to August 15 is not expected to result in suboptimal conditions for migrating and holding adults, as the water temperature is still likely to be in the low 60s (°F) in June. However, water temperatures at the confluence may exceed 68°F more frequently, particularly in July and into August, when a very small proportion (less than 5 percent) of adults are entering Clear Creek. Temperatures greater than 68°F may create a temperature barrier that would likely delay migration for a small proportion of adults entering Clear Creek in July and August, resulting in pre-spawn mortality and reduced spawning success, particularly in critical years.

The 56°F temperature objective will be extended into mid-November when fry are beginning to emerge. The 61°F and 60°F temperature objectives could adversely impact a small proportion of juvenile CV spring-run Chinook salmon in the lowest reach of Clear Creek where water temperatures are warmest. The greatest risk would be during critical or dry water years, when Reclamation may not be able to achieve these temperature objectives.

Overall, the severity of the water temperature stressor is sublethal, the proportion of the population exposed is small, and the frequency of exposure is medium. The proposed action supports the survival of CV spring-run Chinook salmon in Clear Creek, although temperatures are expected to continue to result in delayed migration and mortality to a small proportion of adults.

7.2.1.6.1.2. California Central Valley Steelhead Exposure and Response

7.2.1.6.1.2.1. Exposure (Life Stage Location and Timing)

Migrating adults and rearing juveniles from various year classes are present in Clear Creek during the temperature management period (June through mid-November). Multiple age-classes of juvenile CCV steelhead are distributed throughout Clear Creek year-round. The warmest water temperatures occur during the summer months with potential negative impacts to the returning adults, and rearing juveniles. Depending on the length of exposure, suboptimal water temperatures can affect growth rates, increase risk of predation and susceptibility to disease, inhibit smoltification, and cause direct mortality in all life stages of CCV steelhead (EPA 2003). Specifically for adults, exposure to suboptimal temperatures prior to spawning can inhibit migration, increase susceptibility to disease, reduce egg viability, and increase rates of prespawn mortality.

During July and August, historically the months with the warmest water temperatures observed in Clear Creek, the 2023 HEC-5Q modeling results at Igo and the mouth of Clear Creek showed monthly average water temperatures are generally within optimal ranges for juvenile CCV steelhead rearing and growth (Table 53). Daily average water temperatures from 2004 to 2023 ranged from approximately 55°F to 60°F in July and August at Igo (Figure 67), but generally ranged from approximately 65°F to 70°F near the mouth of Clear Creek at the lowest extent of rearing habitat (Figure 68). The highest density of CCV steelhead spawning occurs in the lower 6 miles of Clear Creek. Any juveniles rearing in the furthest downstream 3 miles during the summer water temperature management period would likely be exposed to warmer water temperatures and lower flows in early summer, increasing their susceptibility to stress, disease, predation, and mortality. The CCV steelhead juvenile out-migration generally does not occur in the summer, so out-migrating juveniles would not be exposed to the warmest water temperatures at the mouth, and rearing juveniles could access upstream habitat with suitable water temperatures.

7.2.1.6.1.2.2. Response

Water temperatures may be suboptimal for adult CCV steelhead during the earliest migration and holding period. Adult CCV steelhead typically enter Clear Creek from September to April. Beginning in mid-September, releases start to increase, and the temperature objective is reduced to 56°F.

Daily average water temperatures near the mouth of Clear Creek generally range from 60-70°F from mid-August to September 15, are below 65°F in September, and decrease to below 60°F consistently beginning in October (Figure 68). Based on a literature review of salmonid water temperature criteria, (Richter and Kolmes 2005) summarized that water temperatures near 70°F block adult steelhead migration, and recommended 60.8°F weekly mean daily temperature and 64.4°F 7DADM as criterion for adult salmonid migration. The EPA recommends migration temperatures between 64.4°F and 68°F 7DADM for Chinook salmon and steelhead to prevent migration blockage and increased risk of disease (EPA 2003).

Because daily average water temperatures at the mouth are generally below 60°F during the majority of the CCV steelhead migration period, and only a small proportion of the annual return

occurs before mid-September when water temperatures exceed optimal ranges, impacts to migrating adult CCV steelhead are expected to minimally affect a small proportion of adults during the water temperature management period. CCV steelhead adults hold in Clear Creek until spawning begins in mid-December and are restricted to downstream of the segregation weir until early November when it is removed. Water temperatures are generally adequate for holding during this time, and are not expected to reduce egg viability or survival of adult CCV steelhead. Due to the winter spawn timing, the CCV steelhead egg/alevin life stages would not be exposed to the proposed action summer or fall temperature management regimes.

In addition to protection for holding adult CV spring-run Chinook salmon, summer temperature management was designed to protect rearing juvenile CCV steelhead that over-summer in Clear Creek. Richter and Kolmes (2005) reported that ideal conditions for CCV steelhead juvenile growth occur below 66.2°F (19°C), and are optimal at 57.2°F to 59°F (14°C to 15°C). The proposed water temperature objective of 61°F from June 1 through August 15 and 60°F from August 16 through September 15 are below the temperatures considered ideal for CCV steelhead growth. Frequency of anadromy in the early freshwater life stages of *O. mykiss* may be influenced by environmental factors, including stream temperatures, genetic factors, and individual condition. Kendall et al. (2014) and Sloat and Reeves (2014) found significantly increased rates of anadromy in juvenile *O. mykiss* reared in warmer temperatures (seasonally adjusted temperatures between 42.8°F and 64.4°F [6°C and 18°C], compared to 42.8°F and 55.4°F [6°C and 13°C]).

7.2.1.6.1.2.3. Summary of Effects (Proportion of Population and/or Frequency/Likelihood of Occurrence)

Based on life history strategy, rearing juvenile CCV steelhead spend 1 to 3 years in Clear Creek, and therefore a large proportion are expected to be present in Clear Creek during the summer months. The majority are expected to access rearing habitat with suitable water temperatures upstream of the Igo compliance point, and a small proportion of juveniles exposed to suboptimal water temperatures would be susceptible to reduced growth and survival. Adult CCV steelhead are not likely to be exposed to the 61°F water temperature objective during June 1 to August 15, since they do not typically enter Clear Creek until September. Meanwhile, extending the 56°F temperature objective into mid-November will likely result in suitable water temperature conditions for spawning adults. During critical water years (16 percent of years) or dry water years (24 percent of years), Reclamation may not be able to achieve the water temperature objectives, particularly in September and October, which is expected to result in suboptimal conditions for a small proportion of spawning adults, resulting in prespawn mortality.

7.2.1.6.2. Effects of Minimum Instream Flow (Seasonally Variable Hydrograph)

Under the proposed action, Reclamation proposes to release variable flows throughout the year, with peak flows of 300 cfs in mid-March declining in incremental steps to 100 cfs in early September. The proposed seasonally variable hydrograph provides a more natural variation and allows higher flows during winter and spring when CV spring-run Chinook salmon eggs are incubating and fry are emerging, and when CCV steelhead adults are holding and spawning, redds are present, and fry are out-migrating.

To accomplish the proposed seasonally variable flows, Reclamation will make releases from Whiskeytown Dam, increasing releases during the winter, and decreasing releases during the summer. Figure 76 shows that expected flows provided by the proposed action (Alt2v1) are as high as 300 cfs in winter months, and as low as 100 cfs in summer and fall months.

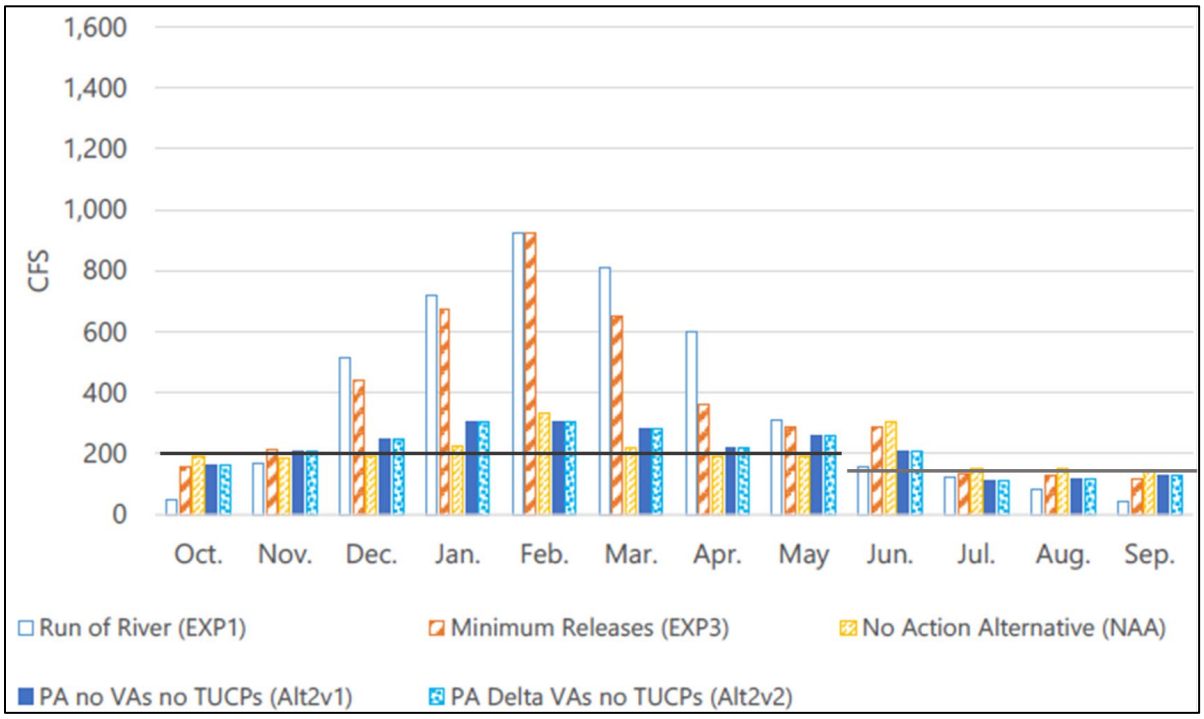


Figure 76. Monthly releases from Whiskeytown Dam for all modeling scenarios. Solid blue bars represent the proposed action (Alt2v1). Black 200 cfs line and gray 150 cfs line added to show current operations.

Source: (U.S. Bureau of Reclamation 2023-2024)

7.2.1.6.2.1. Central Valley Spring-Run Chinook Salmon Exposure and Response

7.2.1.6.2.1.1. Exposure (Life Stage Location and Timing)

Since the proposed variable flows will occur throughout the year, all life stages of CV spring-run Chinook salmon will be affected by the change in seasonal flows. Adult CV spring-run Chinook salmon migrate into Clear Creek primarily from late-April to late-June, with very low rates of adults entering Clear Creek in July and August (Figure 77).

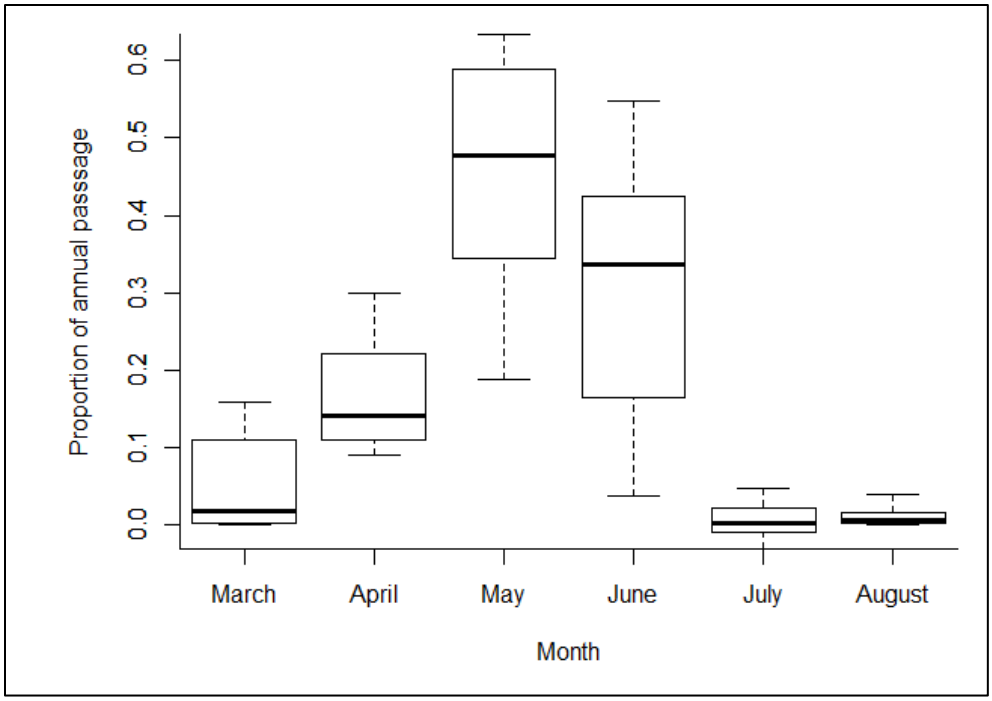


Figure 77. Proportion of annual Central Valley spring-run Chinook Salmon passage by month at the Clear Creek Video Station located near the confluence with the Sacramento River, from 2013 to 2021.

Estimation of 2019 passage by month was not possible due to weir outages from multiple high water events and poor video quality from Carr Fire related turbidity. Estimation also does not include 2022 as the passage into Clear Creek was confounded by fish transferred from the fish trap at Keswick Dam.

Source:(Clear Creek Technical Team 2023)

The low rate of adult migration into Clear Creek in July and August is likely due to the timing of CV spring-run Chinook salmon in the Upper Sacramento tributaries, and temperature-related migration barriers associated with warmer water at the confluence. While the proposed low summer flows would not limit adult holding habitat or passage in the deep pools of canyon reaches, they may restrict upstream passage from the lower alluvial reaches by creating temperature and low flow barriers at riffles and cascades.

Egg incubation occurs primarily from September to November. Fry emergence occurs from late October through January, peaking in December, and a small portion remain in Clear Creek through the spring and summer, and emigrate as sub-yearlings.

The proposed action would result in flows in Clear Creek in the fall and winter up to 300 cfs, which overlaps with the time when juvenile CV spring-run Chinook salmon are rearing in the area, and flows as low as 100 cfs in the summer, towards the end of adult migration upstream and during yearling rearing.

7.2.1.6.2.1.2. Response

WUA provides a metric of CV spring-run Chinook salmon spawning and rearing habitat availability based on water depth, flow velocity, and substrate. To estimate spawning and rearing (WUA) available under the proposed action, Reclamation performed modeled runs using flow-habitat relationship curves with mean monthly CalSim 3 flow estimates. The proposed flows provide approximately 0.2 to 0.3 acres (8,700 to 13,000 square feet) of WUA.

Reclamation provided the following figure (Figure 78) showing expected monthly spawning habitat quantities in September and October under different scenarios with the new flow regime, with the proposed action shown in blue.

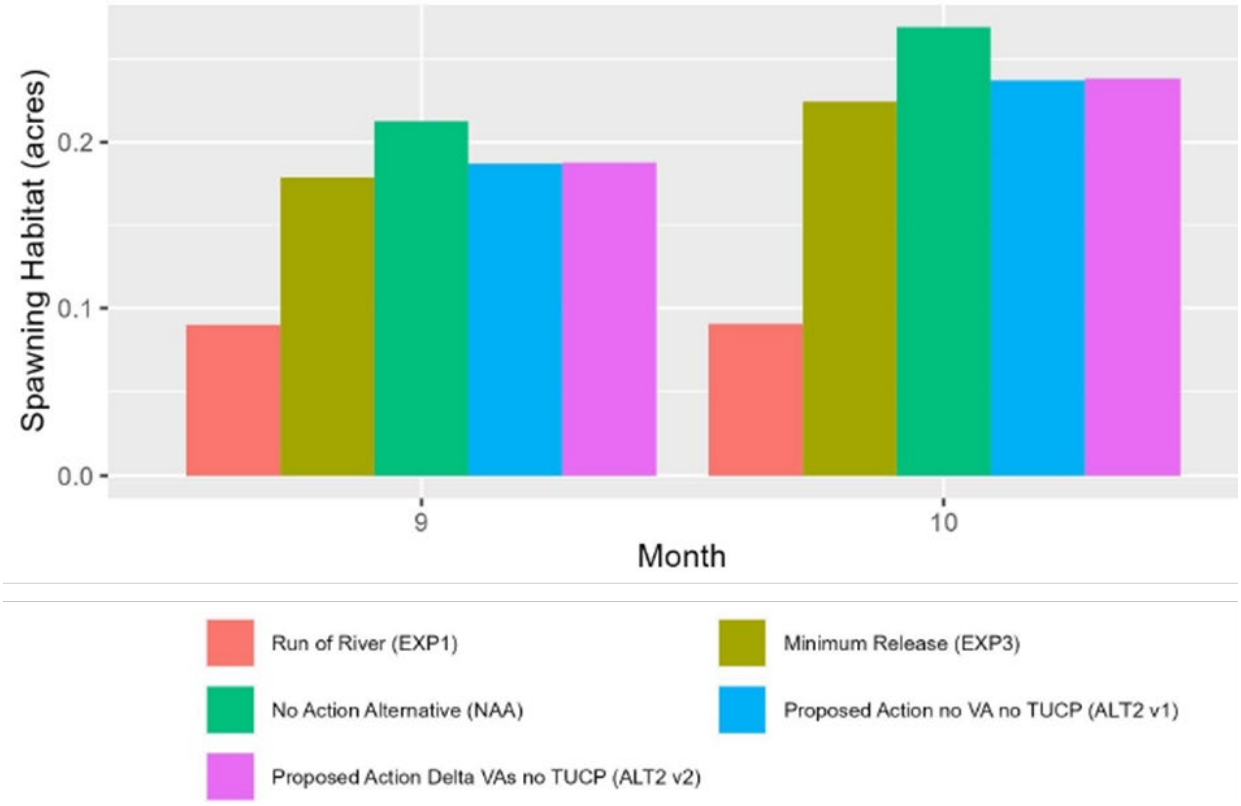


Figure 78. Estimated spawning habitat area for adult Central Valley spring-run Chinook salmon in Clear Creek during September and October. Values represent means across CalSim water years, and do not account for extensive gravel augmentations that have recently occurred.

Source: (U.S. Bureau of Reclamation 2023-2024)

According to (U.S. Fish and Wildlife Service 2015a), minimum spawning habitat needs are approximately 30,000 square feet or 0.7 acres (see red line in Figure 79). Therefore, the anticipated available CV spring-run Chinook salmon spawning habitat under the proposed action is still expected to be limiting. Figure 78 does not account for gravel augmentation, which is

ongoing and is expected to increase spawning WUA for CV spring-run Chinook salmon. Spawning WUA used fall-run Chinook salmon as a proxy for CV spring-run Chinook salmon WUA and peaks at flows of approximately 5,000 cfs in Clear Creek (U.S. Bureau of Reclamation 2023-2024). Overall, the WUA habitat values are lowest in critical water years and highest in the wet water year types.

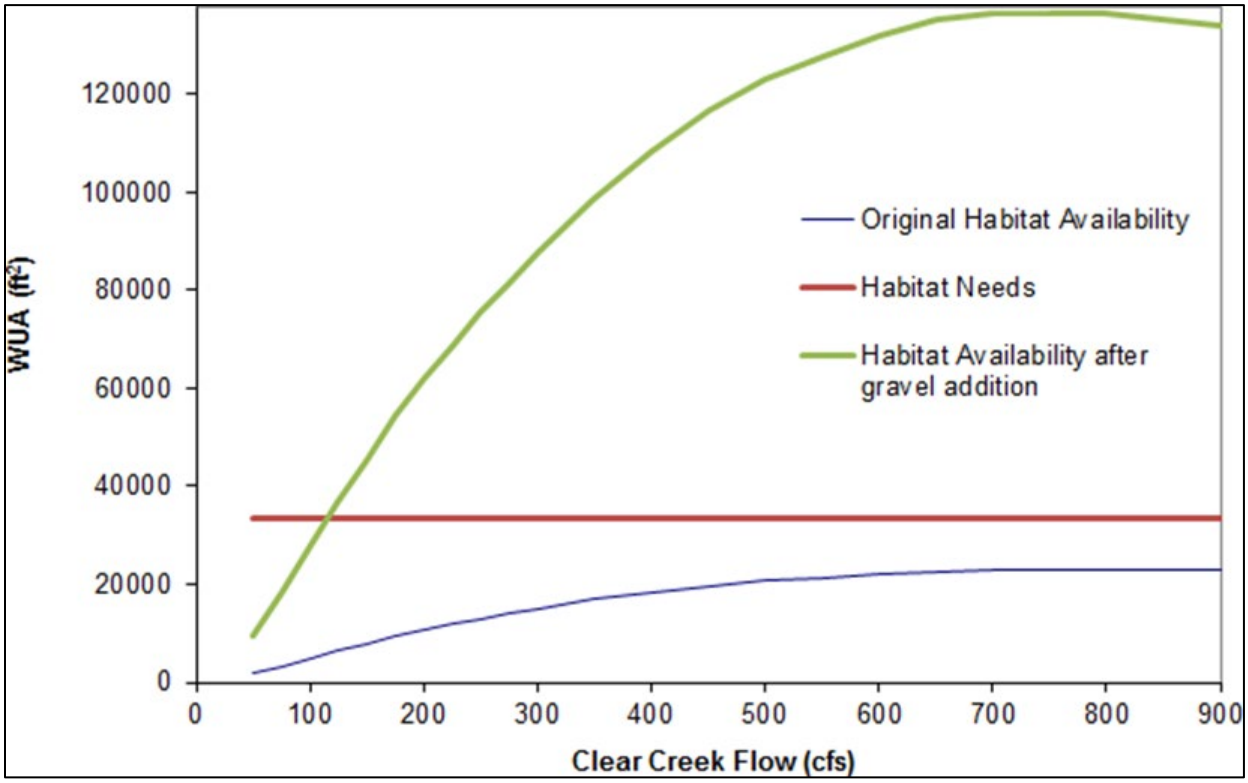


Figure 79. Weighted usable area (WUA) curve which includes the increased spawning habitat availability after gravel addition projects. 120,000 square feet (ft2) is approximately 2.75 acres.

Source: (U.S. Fish and Wildlife Service 2015a)

While the proposed action WUA analysis indicates that spawning habitat is limited given the proposed flows and current population levels, higher flows generally improve water temperatures for incubating eggs. Releases from Whiskeytown Dam will increase in the fall, achieving flows at Igo greater than 200 cfs starting in early-November, when CV spring-run Chinook salmon redds may still be present. Increased flows increase habitat and improve reproductive success, especially when larger populations of spawning CV spring-run Chinook salmon are present in Clear Creek.

In critical water year types (16 percent of years), base flows may be reduced and 56°F daily average water temperature may not be achievable, thereby decreasing the quantity and quality of available spawning habitat for CV spring-run Chinook salmon.

Most juvenile CV spring-run Chinook salmon out-migrate as fry, primarily from November through January, when flows will be higher than other times of the year (175 to 300 cfs). Yearling CV spring-run Chinook salmon may be rearing in Clear Creek over summer when flows are expected to be lowest and water temperatures are warm.

USFWS (2015a) assumes the available habitat for fry is more than sufficient (Figure 80) since they leave the system quickly. However, it is possible that fry exit Clear Creek quickly because the rearing habitat and food availability are limited. Seventy-five percent of fry leave immediately and do not rear in Clear Creek (U.S. Fish and Wildlife Service 2015a).

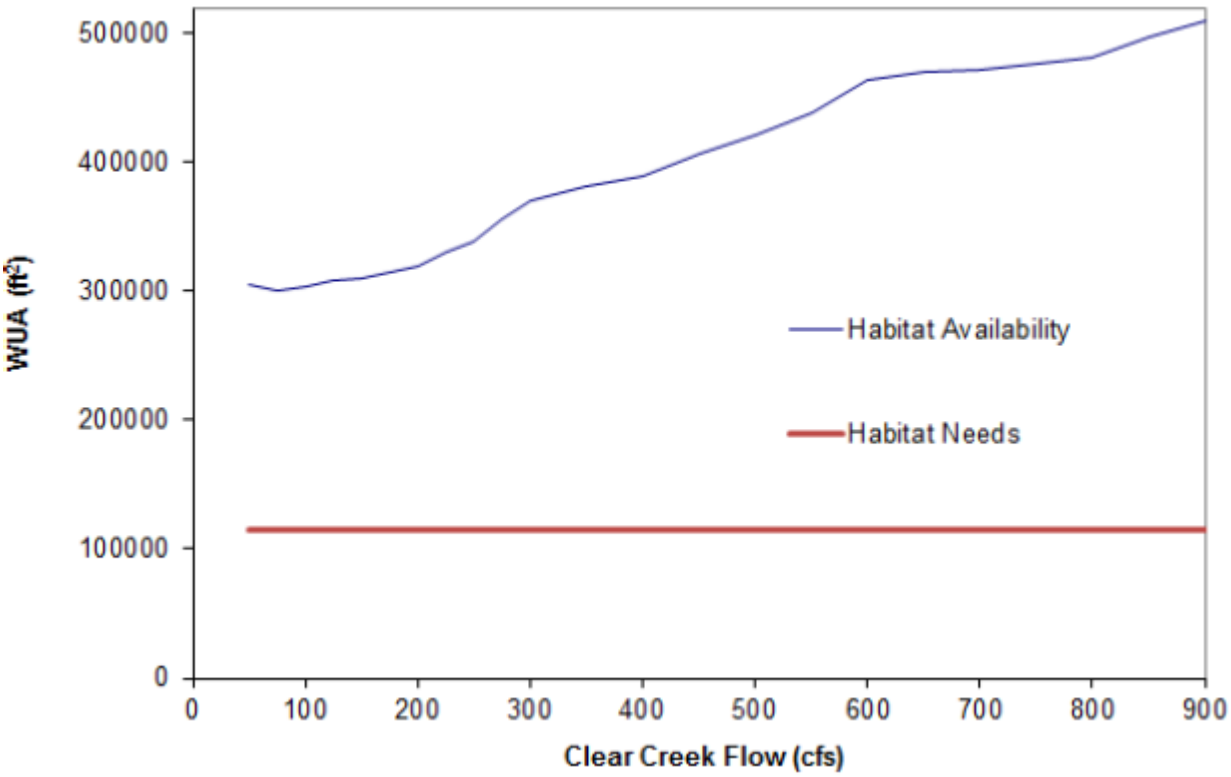


Figure 80. Central Valley spring-run Chinook salmon fry rearing flow-habitat availability relationship and habitat needs.

Source: (U.S. Fish and Wildlife Service 2015a).

The flow regime of the proposed action will increase flows during the period when fry are emerging, resulting in more instream habitat. Increased surface flows are likely to increase hyporheic flows that improve dissolved oxygen and additionally may reduce sedimentation, thereby improving egg and alevin essential functions and development (Bennett 2003). Figure 81 illustrates CalSim 3 mean monthly instream rearing habitat for salmonids.

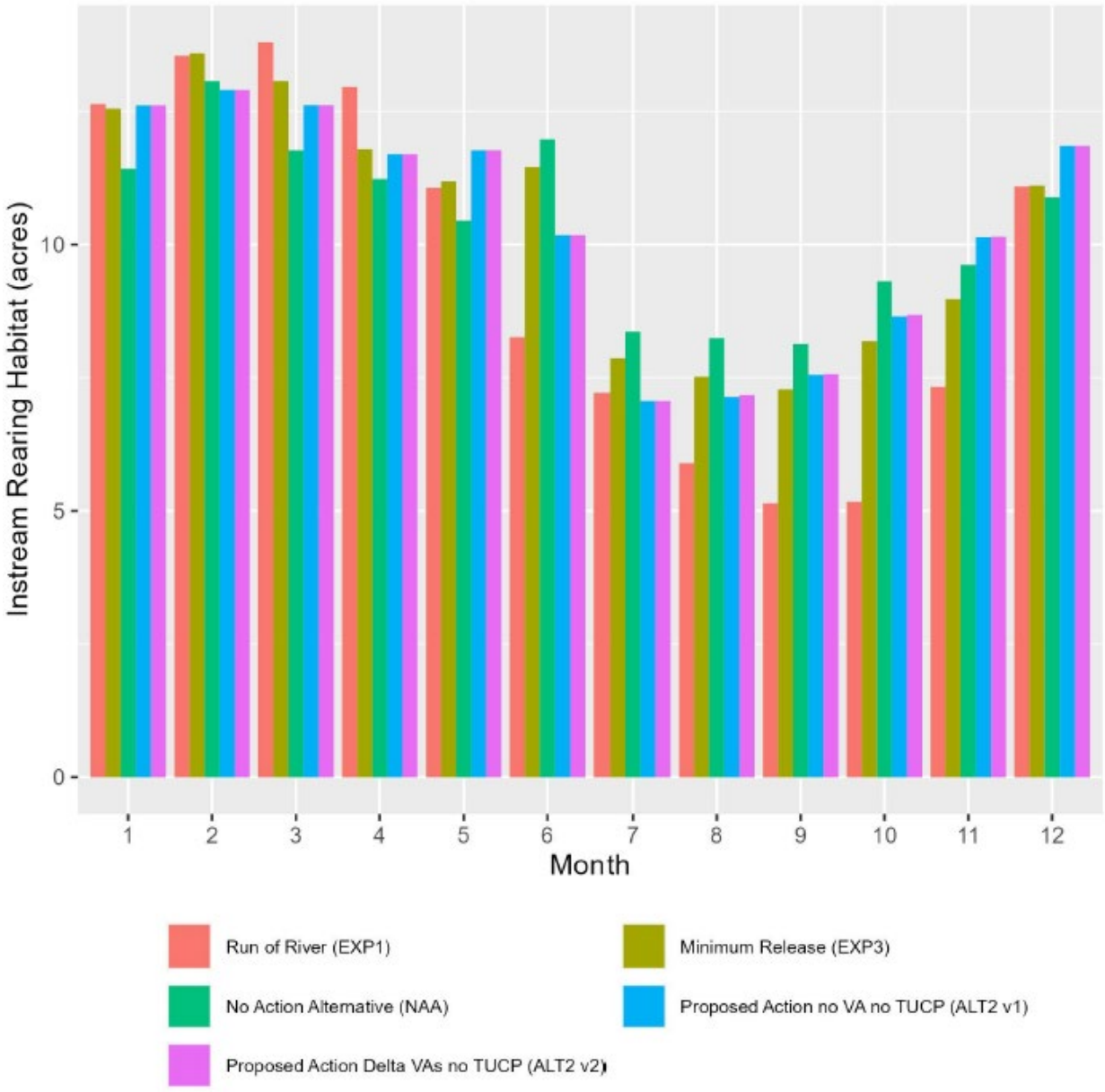


Figure 81. Estimated instream rearing habitat for juvenile salmonids in Clear Creek.

Source: (U.S. Bureau of Reclamation 2023-2024)

Available habitat is greatest at highest flows during winter and spring and lowest during summer and fall flows. When comparing the proposed action WUA values to flow-habitat relationships in (U.S. Fish and Wildlife Service 2015a), the proposed minimum flows are expected to provide adequate rearing habitat for fry.

7.2.1.6.2.1.3. Summary of Effects (Proportion of Population and/or Frequency/Likelihood of Occurrence)

Reducing flows down to 100 cfs starting in July would likely create a passage impediment for late-arriving adult CV spring-run Chinook salmon at the confluence of the Sacramento River and Clear Creek due to warm water temperatures. Water temperatures greater than 68°F may create a passage barrier and delay a small proportion of migrating adults entering Clear Creek in July and August, resulting in pre-spawn mortality and reduced spawning success. Low flows can also create a passage barrier at shallow riffles and cascades, delaying or preventing a small proportion of late-arriving spawning adults from accessing upstream habitat, resulting in decreased survival and reduced spawning success.

Because of the timing of out-migration, a large proportion of out-migrating fry would experience suitable flows, greater available habitat, and an increase in food availability during November to March. A small proportion of over-summering juvenile CV spring-run Chinook salmon would have less accessible habitat during the summer and fall that may result in decreased food availability and refuge habitat. This is expected to result in decreased survival and fitness for a small proportion of CV spring-run Chinook salmon.

7.2.1.6.2.2. California Central Valley Steelhead Exposure and Response

7.2.1.6.2.2.1. Exposure (Life Stage Location and Timing)

Adult CCV steelhead typically migrate into Clear Creek in September through April. The segregation weir, located at river mile 8.2, is removed in early-November, prior to CCV steelhead spawning. CCV steelhead spawning begins in mid-December and continues through April, with peak spawn timing occurring from mid-December through early February. Spawning is distributed throughout the creek, with the majority of redds located downstream of river mile 6 in recent years (Schaefer et al. 2019). Egg and alevins are present in redds from mid-December through June. Emergent fry are first observed in the rotary screw traps in mid-January and peak fry out-migration occurs during April and May (Schraml et al. 2018). Juvenile CCV steelhead are captured during all months of monitoring, which occurs from November through June (Schraml et al. 2018).

Underwater observational surveys for various studies and fish rescue operations during restoration work by the USFWS have also documented the presence of juvenile CCV steelhead in the summer and fall months. Multiple year classes of juvenile CCV steelhead rear in Clear Creek year-round and are distributed throughout the entire length of the creek. Based on rotary screw trap catch, smolts account for a low proportion of the juvenile passage indices. For example, in 2012, smolts accounted for 1.4 percent passage and were observed January through May (Schraml et al. 2018). However, larger-sized juveniles and smolts more easily avoid the rotary screw traps, and passage estimates may underestimate these life stages.

7.2.1.6.2.2.2. Response

Recent years have shown a decrease in total suitable spawning habitat in Clear Creek. The most recent annual survey in July 2023 observed depleted gravel injection sites in the upstream reaches of Clear Creek. Much of the suitable spawning habitat attributable to the injected gravel

was found downstream. Lower in the canyon reach, spawning habitat appeared in a new location (river mile 14.6 to 14) as shown in Figure 82. It is likely this is the resting place for the injection gravel that got transported from upstream.

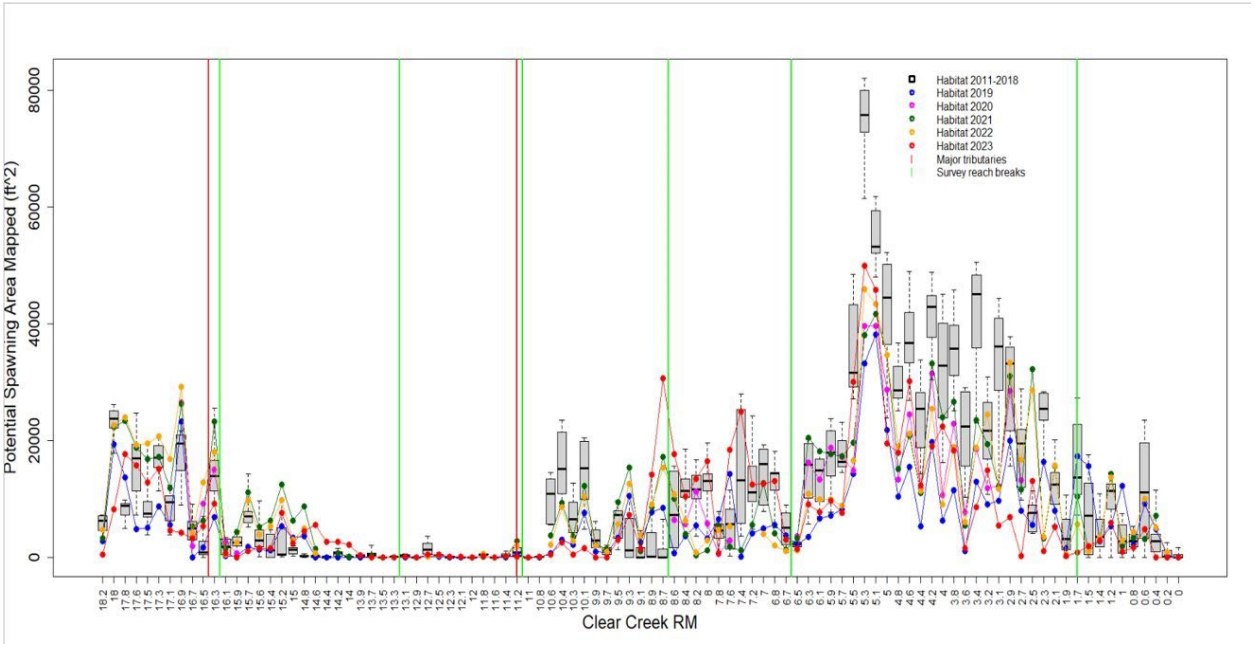


Figure 82. Anadromous fish spawning habitat mapped on Clear Creek 2011–2023.

The X-axis indicates Clear Creek river mile breaks of roughly 1,000 feet. The Y-axis indicates the magnitude of habitat within each break. Years 2011–2018 are displayed by boxplot, 2019-2023 are presented as points showing habitat in the given year. River mile (RM) 0 is on the far right side of the X-axis, and RM 18 at the most upstream extent at Whiskeytown Dam is on the far left. Suitable habitat is located between river mile 18.2-14.6 and 10.4-0.4 with little suitable habitat between river mile 14.4-10.8.

Source: Figure 19 from (Clear Creek Technical Team 2023)

Modeling results show the flow-habitat relationship in Clear Creek; however, not all substrate is suitable for spawning, as shown in Figure 82. Gravel augmentation is expected to continue to occur, which will add suitable spawning gravel to upstream locations. During winter and spring, releases from Whiskeytown Dam will increase, resulting in greater amounts of inundated habitat for spawning and rearing. Increased flows from cold water reservoir releases are expected to decrease water temperatures, which will likely increase dissolved oxygen. High flows on Clear Creek have greater potential to inundate floodplain habitat and side channels. Invertebrate abundance is much greater in off-channel habitats compared to in-river channels (Cordoleani et al. 2022).

According to Figure 83, the proposed action is expected to provide approximately 2 acres (87,000 square feet) of spawning habitat for CCV steelhead from January through April, which is adequate for supporting CCV steelhead.

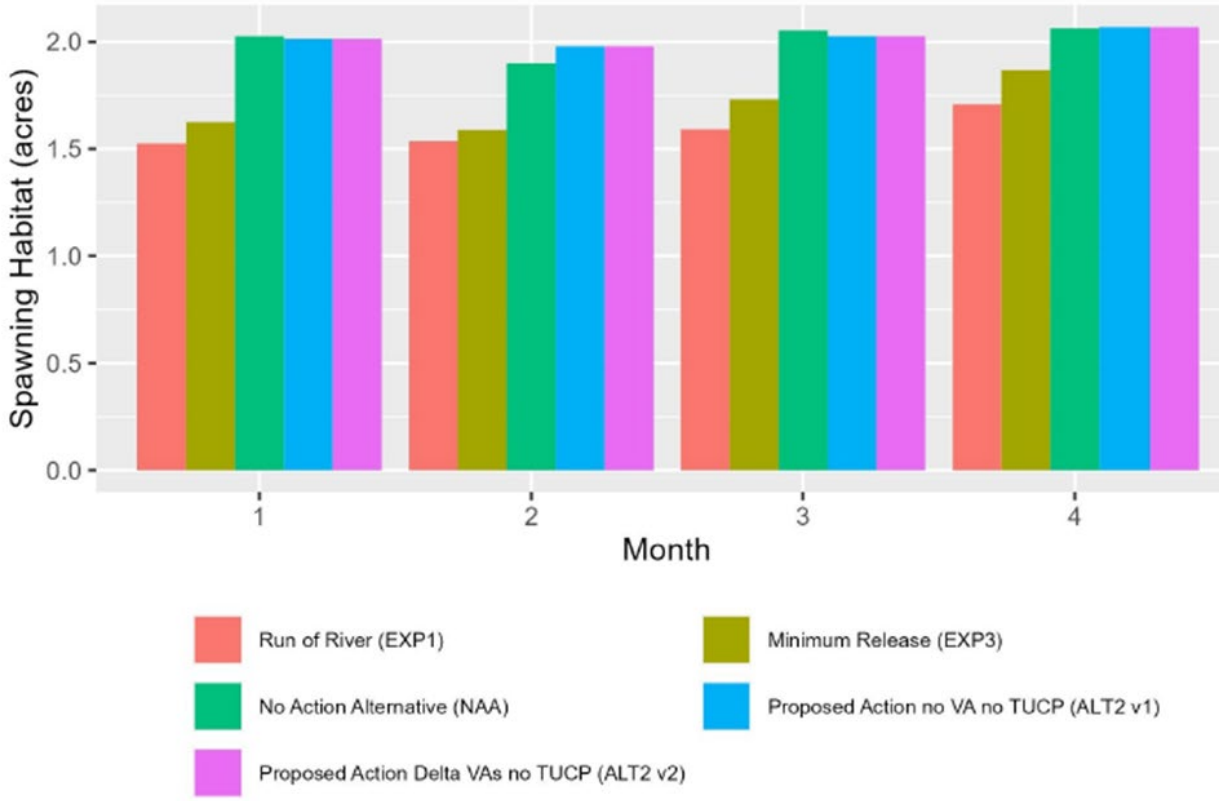


Figure 83. Estimated spawning habitat area for adult California Central Valley steelhead in Clear Creek.

Source: (U.S. Bureau of Reclamation 2023-2024)

During summer and fall, reduced flows would decrease the seasonally inundated habitats, altering food web processes and riparian vegetation, decreasing food availability and quality, and impacting the successful growth and survival of juveniles (Jeffres et al. 2008, Goertler et al. 2018). Decreased flows are expected to decrease food availability, which would reduce growth rates and survival for rearing juvenile salmonids. Table 54 shows the anticipated available WUA under the proposed action meets the habitat needs for rearing juveniles under all water year types.

Table 54. Expected Weighted Usable Area (square feet) for juvenile California Central Valley steelhead rearing in Clear Creek.

Source: Appendix O: Tributary Habitat Restoration in (U.S. Bureau of Reclamation 2023-2024)

Water Year Type	EXP3	NAA	Alt2v1	Alt2v2
Wet	36,405	33,925	31,784	31,781

Water Year Type	EXP3	NAA	Alt2v1	Alt2v2
Above Normal	35,065	33,310	31,466	31,466
Below Normal	29,015	32,859	30,476	30,340
Dry	25,273	33,710	31,520	31,520
Critical	20,703	29,924	27,203	27,257
All	29,703	32,955	30,708	30,691

7.2.1.6.2.2.3. Summary of Effects (Proportion of Population and/or Frequency/Likelihood of Occurrence)

A large proportion of adult CCV steelhead would experience adequate flows and habitat conditions for successful migration and spawning. Similarly, a large proportion of eggs and fry are expected to experience adequate conditions in Clear Creek. A small proportion of out-migrating juveniles and rearing yearlings would experience suboptimal water temperatures and reduced flows during the summer and fall. Reduced flows are also expected to result in reduced prey richness (Dewson et al. 2007) and smaller prey size, which would increase food searching time (Caldwell et al. 2018) for a small proportion of juveniles in Clear Creek, resulting in reduced survival and fitness.

7.2.1.6.3. Effects of Spring Attraction and Channel Maintenance Pulse Flows

Reclamation is proposing to allocate a total of 10,000 acre-feet to be used for all spring attraction pulse flows and a channel maintenance pulse flow, with a daily release up to the safe release capacity (approximately 840 cfs). In critical years, Reclamation will release up to 5,000 acre-feet for pulse flows. The purpose of spring attraction pulse flows is to create hydrologic and temperature cues that mimic natural conditions, to encourage adult CV spring-run Chinook salmon to enter Clear Creek from the Sacramento River and attract them to the furthest upstream habitats for holding and spawning where they can access colder water temperatures, large and remote holding pools, and newly provided, clean spawning gravel. In years when a significant number of adult CV spring-run Chinook salmon are detected, snorkel survey and video monitoring data have shown that pulse flow releases have been successful (Clear Creek Technical Team 2023).

Channel maintenance pulse flows will occur in winter or spring and will be scheduled for on or after February 1. The purpose of a channel maintenance pulse flow is to provide a high flow event that will enable geomorphic processes in the channel (i.e., dispersal of gravel and mobilization of fine sediment) and improve salmonid habitat for spawning and rearing. While the magnitude is significantly less than the 3,000 to 4,000 cfs recommended for sediment transport and floodplain inundation and the 4,000 to 6,000 cfs for channel formation (U.S. Bureau of Reclamation and ESSA Technologies Ltd 2008), flows up to the limit of 840 cfs would provide

some benefit to sediment transport and improve salmonid habitat. In an evaluation of sediment transport in Clear Creek, Graham Matthews & Associates (2013) showed that spring attraction pulse flows near 1,000 cfs mobilized supplemental spawning gravel.

7.2.1.6.3.1. Central Valley Spring-Run Chinook Salmon Exposure and Response

7.2.1.6.3.1.1. Exposure (Life Stage Location and Timing)

The proposed spring attraction pulse flows coincide with the adult CV spring-run Chinook salmon migration in Clear Creek, which spans from April through August, and peaks in May and June. Exposure of adult CV spring-run Chinook salmon to pulse flow conditions is dependent on both the timing of scheduled releases and adult returns. Since the spring attraction pulse flows would not occur during CV spring-run Chinook salmon spawning and egg incubation, these life stages would not be exposed to the effects of the pulse flows.

When a channel maintenance pulse flow occurs in March or April, a medium proportion (approximately 15 percent as shown in Figure 77) of returning adult CV spring-run Chinook salmon population are expected to be present in Clear Creek. The majority of juvenile CV spring-run Chinook salmon emigrate by February, and channel maintenance pulse flows are scheduled after February 1, so the majority of juveniles would not likely be exposed to the effects of the channel maintenance pulse flows.

7.2.1.6.3.1.2. Response

Increased flow releases of up to 840 cfs in the spring, when base flows are decreasing and water temperatures are warming, create migration cues for adult CV spring-run Chinook salmon and improve passage conditions by cooling water temperatures, increasing turbidity, and improving passage routes. Improved passage and migratory cues likely increase numbers of adult CV spring-run Chinook salmon into Clear Creek and encourage upstream migration to holding pools in the coldest habitat, which would likely increase reproductive success. Releasing cold water from Whiskeytown Dam cues adult CV spring-run Chinook salmon to enter Clear Creek from the Sacramento River to reach furthest upstream habitats for holding and spawning. Warm water temperatures between pulses may encourage adults to move further upstream (Clear Creek Technical Team 2024).

Spring attraction pulse flows have been implemented on Clear Creek annually since 2010, and monitoring has indicated some success. Pulse flow events have successfully attracted CV spring-run Chinook salmon into Clear Creek at higher rates than the periods without pulse flows in some years (Clear Creek Technical Team 2023). Surveys conducted before and after pulse flows have shown that the distribution of holding CV spring-run Chinook salmon in Clear Creek shifts upstream as a result of the pulse flows (Clear Creek Technical Team 2021). During springtime channel maintenance pulse flows, attraction of earlier arriving adult CV spring-run Chinook salmon to Clear Creek could increase returns, encourage movement to the preferred upstream reaches, and result in a larger spawning population and increased genetic diversity.

Rotary screw trap data have shown that 97 percent of juvenile CV spring-run Chinook salmon emigrate as fry, with peak migration in November and December (Earley et al. 2013, Schraml et al. 2018). The remaining cohort rearing in Clear Creek would be exposed to the effects of spring

attraction pulse flows annually. Spring attraction pulse flows are expected to benefit juvenile CV spring-run Chinook salmon by improving downstream passage. Rearing juvenile CV spring-run Chinook salmon have been observed in Clear Creek throughout the spring and summer months during snorkel surveys. While this life history variation appears to represent a small fraction of rotary screw trap passage estimates, these individuals may contribute significantly to the returning adult populations.

7.2.1.6.3.1.3. Summary of Effects (Proportion of Population and/or Frequency/Likelihood of Occurrence)

Adult CV spring-run Chinook salmon that migrate into Clear Creek may stage and hold in the lower reaches rather than migrating further upstream. These individuals would, therefore, be susceptible to negative effects from warmer water and introgression with fall-run Chinook salmon. Continued implementation of spring attraction pulse flows in the proposed action in June is expected to provide increased opportunity for adult passage during the lower base flow period.

Channel maintenance pulse flows are expected to provide long-term benefits, improving spawning habitat by mobilizing and dispersing gravel, and reducing fine sediment. During spawning, channel maintenance pulse flows may cause scour or fine sediment infiltration of CV spring-run Chinook salmon redds that may still be present in early February. Still, the proposed channel maintenance pulse flows (unless coupled with storm events) are low enough in magnitude, and are not likely to cause high rates of redd scour. Temperature-based egg-to-fry emergence data and rotary screw trap monitoring data have shown the majority of CV spring-run Chinook salmon fry emerge and begin to migrate downstream in November and December in Clear Creek. However, based on temperature-based emergence dates, a low percentage of redds are expected to contain incubating eggs/pre-emergent fry after February 1, and a small proportion is expected to result in mortality in years when channel maintenance pulse flows occur.

Spring attraction pulse flows are expected to contribute to suitable habitat conditions for the small proportion of juvenile CV spring-run Chinook salmon that may still be in Clear Creek by improving downstream passage. Pulse flows increase turbidity and velocity, cool water temperatures, and create cues for out-migration. Improved out-migration conditions are expected to reduce stress, disease, predation rates, and thereby improve survival. Pulse flows temporarily provide access to juvenile rearing habitat within floodplains and side channels, which may increase the variety of available food (Matousek 2007). Spring attraction pulse flows may also displace juveniles downstream into warmer water habitat, which may increase risk of predation, disease, and mortality.

Each year, during spring attraction and channel maintenance pulse flows, we expect improved conditions for a small proportion of juveniles expected to out-migrate, decreased survival to a small proportion of displaced juveniles that remain in the lower reaches, and decreased survival of a small proportion of juveniles subject to stranding. Pulse flows are also expected to affect a large proportion of adult CV spring-run Chinook salmon by improving upstream passage conditions, improving survival, and improving spawning habitat, thereby increasing survival of eggs and increasing production.

7.2.1.6.3.2. California Central Valley Steelhead Exposure and Response

7.2.1.6.3.2.1. Exposure (Life Stage Location and Timing)

Adult CCV steelhead typically migrate into Clear Creek from September to April and will therefore be present during channel maintenance pulse flows, but are not expected to be present during spring attraction pulse flows. The CCV steelhead redds may be present in Clear Creek from December to May. The fry out-migration typically begins in late January or early February and peaks during the months of April and May (Schraml et al. 2018). Rearing juvenile CCV steelhead are present throughout Clear Creek during the pulse flows. Multiple year classes of juvenile CCV steelhead rear in Clear Creek year-round and are distributed throughout the entire length of the creek. Juvenile CCV steelhead rear in freshwater from 1 to 3 years (Moyle 2002).

7.2.1.6.3.2.2. Response

Channel maintenance pulse flows could improve passage conditions for adult CCV steelhead by increasing turbidity and providing higher flows, thereby improving passage routes. Improved passage and migratory cues may increase numbers of adult CCV steelhead into Clear Creek. However, these pulse flows would occur in winter or spring when release from Clear Creek would already be relatively high and may not have a noticeable benefit to adult CCV steelhead.

Channel maintenance pulse flows are expected to provide long-term improvements to spawning habitat by mobilizing and dispersing gravel and reducing fine sediment. During spawning, channel maintenance pulse flows may cause scour or fine sediment infiltration of CCV steelhead redds that may be present after February 1. The proposed channel maintenance flows (unless coupled with storm events) are low enough in magnitude and not likely to cause high rates of redd scour. Redds are typically present from December to May. During a 2015 to 2016 survey, over 90 percent of the annual CCV steelhead redds were observed by mid-February (Schaefer et al. 2019). Although this is a single year of data and during a drought year, this survey provides insight on redd timing and suggests that a small proportion of redds may be exposed to fine sediment infiltration, increasing the risk of mortality of incubating eggs.

Spring attraction pulse flows occur during a time when smolts have been observed out-migrating in Clear Creek. Yearlings rear in Clear Creek year-round. Pulse flows would provide rearing juvenile CCV steelhead temporary access to rearing habitat within side channels. Increased flows, increased turbidity, and cooler water temperatures create migration cues, improve downstream passage conditions, reduce predation, and improve survival of smolts. Available rearing habitat (WUA) for juvenile CCV steelhead increases from approximately 200,000 square feet at minimum flows to 700,000 square feet when flows are nearing 900 cfs (Figure 84, U.S. Fish and Wildlife Service 2015a).

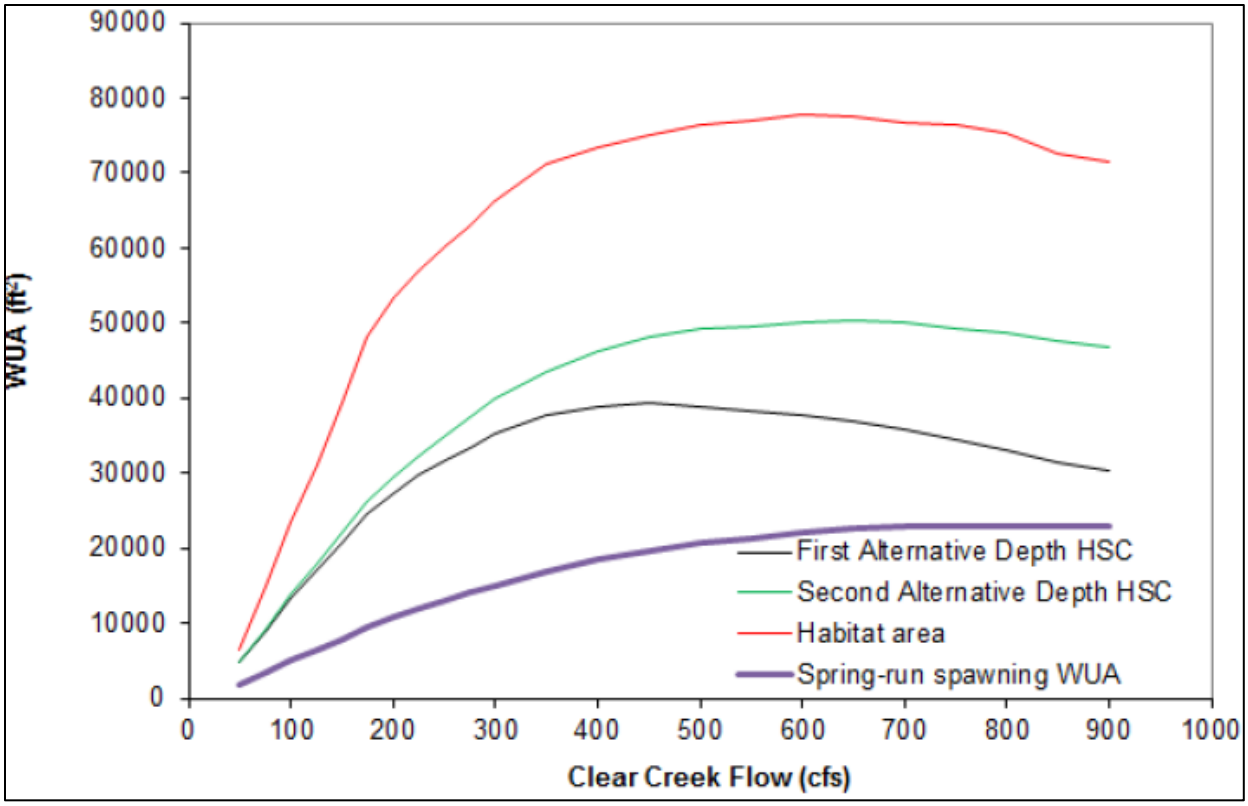


Figure 84. Flow-habitat relationships for spawning in Clear Creek.

WUA = weighted usable area; ft^2 = square feet; cfs = cubic feet per second; HSC = habitat suitability criteria.
Source: (U.S. Fish and Wildlife Service 2015a)

Though short lived, the pulses may provide access to new food sources not normally available during low flows and could improve the growth and survival (Matousek 2007) of a large proportion of juvenile CCV steelhead present in the springtime. Conversely, juveniles may be displaced downstream during pulse flows and after flows decrease. If they remain in unsuitable habitat, they would likely be exposed to warmer water temperature and be at risk of increased predation, disease, and mortality.

7.2.1.6.3.2.3. Summary of Effects (Proportion of Population and/or Frequency/Likelihood of Occurrence)

A large proportion of migrating and spawning adult CCV steelhead would be present during channel maintenance pulse flows and are expected to have long-term benefits to spawning habitat, improving spawning success. Higher flows may also provide a small improvement to passage to a large proportion of adults, improving survival and fitness. During spring attraction pulse flows, a small proportion of the redds would be exposed to fine sediment infiltration, increasing the risk of mortality of incubating eggs, and a small proportion of juveniles are expected to become stranded or isolated. Pulse flows may also temporarily improve prey availability for juveniles. Therefore, we expect increased survival and fitness of a large proportion of CCV steelhead rearing juveniles and out-migrating smolts, in addition to decreased

survival to a small proportion of juveniles that remain in the lower reaches after spring-pulse flows. A small proportion of juveniles would also be subject to stranding after the pulse flows recede.

7.2.1.6.4. Effects of Ramping Rates

Reclamation proposes to continue operating with ramp down rates of up to 25 cfs per hour. This reduces the risk of stranding of juvenile salmonids and fits within the precision of the constraints of the operation of the outlets.

7.2.1.6.4.1. Central Valley Spring-Run Chinook Salmon Exposure and Response

7.2.1.6.4.1.1. Exposure (Life Stage Location and Timing)

During spring attraction and channel maintenance pulse flows, ramp down rates of up to 25 cfs per hour will be implemented. The spring attraction flows occur in May and June, which overlaps with adult CV spring-run Chinook salmon migration into Clear Creek. A small proportion of juveniles are expected to be rearing and out-migrating during this time. During channel maintenance pulse flows, a small proportion of early returning adult CV spring-run Chinook salmon in the Clear Creek population may be present in Clear Creek. The majority of juveniles typically emigrate by February and would not be exposed to the effects of the channel maintenance pulse flow ramp down rates. A small proportion of juveniles may be present in Clear Creek through the spring and summer months, and these individuals would be exposed to flow reductions that are restricted to 25 cfs per hour.

7.2.1.6.4.1.2. Response

During pulse flow ramp down, adult and juvenile CV spring-run Chinook salmon may become stranded and isolated from the creek and succumb to predation or desiccation. Since ramp down rates will be implemented, the risk of stranding would be reduced, minimizing negative impacts on survival from flow decreases for any listed fish that are present.

7.2.1.6.4.1.3. Summary of Effects (Proportion of Population and/or Frequency/Likelihood of Occurrence)

A small proportion of CV spring-run Chinook salmon are expected to die as a result of stranding during/after pulse flows (since stranded juveniles can die from desiccation, high temperatures, low dissolved oxygen, or higher levels of predation in a habitat disconnected from the main channel after flow reductions). Pulse flow ramp down rates of no more than 25 cfs per hour are expected to minimize stranding of a large proportion of adults and a small proportion of out-migrating juveniles, resulting in improved survival and fitness.

7.2.1.6.4.2. California Central Valley Steelhead Exposure and Response

7.2.1.6.4.2.1. Exposure (Life Stage Location and Timing)

During spring attraction pulse flows, a medium proportion of CCV steelhead eggs would still be incubating from April through June. Rearing juvenile CCV steelhead are present throughout Clear Creek during the spring attraction pulse flows. Multiple year classes of juvenile CCV

steelhead rear in Clear Creek year-round and are distributed throughout the entire length of the creek.

7.2.1.6.4.2.2. Response

When flows recede at the end of a pulse flow, juveniles may become stranded and isolated from the creek and succumb to predation or desiccation. Ramp down rates will be implemented, which will reduce stranding risk and minimize negative impacts on survival from flow decreases. A large proportion of CCV steelhead juveniles are expected to be present when channel maintenance pulse flow down ramp rates occur, although channel maintenance pulses flows would not occur in dry or critical water year types (9 of the last 20 years). A small proportion of juveniles are expected to be present during spring attraction ramp down rates. Although down ramping rates will be implemented, a small proportion of juveniles are still expected to become stranded or isolated.

7.2.1.6.4.2.3. Summary of Effects (Proportion of Population and/or Frequency/Likelihood of Occurrence)

A large proportion of rearing juvenile CCV steelhead would be present between January and April, and in years when channel maintenance flows occur, they are expected to support rearing juveniles and out-migrating smolts.

With the implementation of ramping rates, we expect improved survival and fitness of a high proportion of CCV steelhead rearing juveniles and out-migrating smolts.

7.2.1.7. Division Effects Summary

Table 55, Table 56, Table 57, Table 58, and Table 59 summarize the project-related stressors for each species and component of the proposed action. These tables capture the response of individuals to each action component, the severity of the effect (lethal, sublethal or beneficial), the expected proportion of the population affected, the frequency of the exposure, and the magnitude of the effect. These effects are based on evaluation of the conditions provided by the implementation of the proposed action (Alt2v1).

Table 60 and Table 61 describe the life stages, primary stressors and effect pathways, and relevant management actions for each operational season on the Clear Creek. The purpose of these tables is to succinctly summarize the primary consequences of the proposed action without comparison to other scenarios or conditions. These effects that are summarized in Table 60 and Table 61 also will be carried forward to the Integration and Synthesis section of the opinion.

Table 55. Summary of Clear Creek operation-related effects on adult Central Valley spring-run Chinook salmon.

Action Component	Stressor/ Factor	Individual Response and Rationale of Effect	Severity of Stressor	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence
Water Temperature Management (June-August)	Water temperature, spawning habitat, pathogens & disease	Warm water temperatures >68°F at the confluence may block or inhibit upstream migration	Sublethal	Small	Medium	Low	Low
Water Temperature Management (September - October)	Water temperature, spawning habitat redd quality, spawning habitat	Adults exposed to >60°F may cause stress, disease, reduced fecundity, prespawn mortality	Minor to lethal	Medium	Medium	Medium	Medium
Minimum Instream Flow	Migration cues, spawning habitat, water temperature	Low flow barriers at riffles and cascades may inhibit access to holding locations	Minor	Small	High	Medium	Low
Spring Pulse Flows	Migration cues, spawning habitat, stranding, water temperature	Increased flows create migration cues by increasing turbidity, decreasing water temperatures, and improving passage of physical barriers to the most upstream reaches	Minor	Large	Medium	Medium	Medium
Channel Maintenance Pulse Flow	Migration cues, spawning habitat, stranding, water temperature	Increased releases create migration cues by increasing turbidity, decreasing water temperatures, and improving passage of physical barriers to the most upstream reaches	Minor	Medium	Small	Small	Medium

Action Component	Stressor/ Factor	Individual Response and Rationale of Effect	Severity of Stressor	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence
Ramp Down Rates	Stranding & Dewatering	Ramp down rates provide time for adults to leave side channels and access the main creek to avoid being stranded	Minor	Large	Medium	Medium	Low

Table 56. Summary of Clear Creek operation-related effects on juvenile Central Valley spring-run Chinook salmon.

Action Component	Stressor/ Factor	Individual Response and Rationale of Effect	Severity of Stressor	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence
Water Temperature Management (June - August)	Pathogens & disease, water temperature	Temperatures may be above optimal growth and survival >65°F. Increased stress, risk of predation and disease	Minor	Small	High	Low	Medium
Minimum Instream Flow	Food availability, refuge habitat	Increased refuge habitat for rearing juveniles during fall/winter, decreased refuge habitat for a portion of rearing yearlings during summer	Minor	Small	High	Medium	Medium
Spring Attraction Pulse Flows	Migration cues, water temperature, refuge habitat	Increased flows create migration cues and improve downstream passage by decreasing water temperatures, increasing turbidity. Provide temporary access to additional rearing habitat	Minor	Small	Medium	Low	Medium
Channel Maintenance Pulse Flow	Migration cues, water temperature, refuge habitat	Temporary access to rearing habitat, out-migration cues.	Minor	Small	Low	Low	Medium

Action Component	Stressor/ Factor	Individual Response and Rationale of Effect	Severity of Stressor	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence
Ramp Down Rates	Stranding	Displacement stranding minimized with ramp down rates	Low	Medium	Medium	Medium	Medium

Table 57. Summary of Clear Creek operation-related effects on adult California Central Valley steelhead.

Action Component	Stressor/ Factor	Individual Response and Rationale of Effect	Severity of Stressor	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence
Water Temperature Management (June - August)	Water Temperature, spawning habitat, pathogens & disease	Temperatures may be suboptimal for a small proportion of adults entering Clear Creek in early September, increasing stress and risk of disease	Sublethal	Small	Low	Low	Medium
Water Temperature Management (September - October)	Water temperature, redd quality, spawning habitat, pathogens & disease	Temperatures may be suboptimal for a small proportion of adults entering Clear Creek in September, and optimal for adults entering in November	Sublethal	Small	Low	Low	Medium
Minimum Instream Flow	Migration cues, spawning habitat, water temperature	A large proportion of adults would experience higher flows from releases up to 300 cfs resulting in adequate amounts of habitat and likely cooler water temperatures	Minor	Large	High	High	Low
Channel Maintenance Pulse Flow	Spawning habitat	create migration cues, and increase turbidity and passage routes and improve spawning habitat by mobilizing gravel and reducing fine sediment	Minor	Medium	Medium	Medium	Medium

Table 58. Summary of Clear Creek operation-related effects on California Central Valley steelhead egg-to-fry.

Action Component	Stressor/ Factor	Individual Response and Rationale of Effect	Severity of Stressor	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence
Minimum Instream Flow	Migration cues, spawning habitat, water temperature	Releases up to 300 cfs in winter would provide adequate spawning habitat and water temperatures for eggs and fry. Base flow reductions in critical water year types may degrade water quality conditions for redds and fry	Minor Sublethal during critical years	Medium	Medium Low during critical years	Medium	Medium
Channel Maintenance Pulse Flow	Spawning habitat	Transport sediment can expose redds to infiltration of fine sediment or scour redds	Sublethal to lethal	Small	Medium	Medium	Low
Ramp Down Rates	Stranding & Dewatering	Ramp down rates are expected to reduce stranding and dewatering of fry. Eggs are not mobile and therefore would still be susceptible to stranding if redds were created during a pulse flow	Minor	Medium	Low	Medium	Low

Table 59. Summary of Clear Creek operation-related effects on juvenile California Central Valley steelhead.

Action Component	Stressor/ Factor	Individual Response and Rationale of Effect	Severity of Stressor	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence
Water Temperature Management (June - August)	Water temperature	Exposure of 1°F warmer temperature in June resulting in suboptimal temperatures (>61°F) downstream of Igo could increase thermal stress	Sublethal	Small	Medium	Low	Low
Water Temperature Management (September - October)	Water temperature	Less frequent Suboptimal temperatures cause a reduction in stress	Minor	Small	Low	Low	Low
Minimum Instream Flow	Water flow, water temperature, habitat and prey availability	Most juveniles would have sufficient conditions during higher flows in spring, resulting in adequate habitat and prey availability, and cooler water temperatures	Minor	Small	High	High	Medium
Minimum Instream Flow	Water flow, water temperature, habitat and prey availability	A small proportion of juveniles would experience warm water temperatures and reduced flows during the summer and fall	Sublethal during summer and fall	Small	Low	Low	Medium
Spring Attraction Pulse Flows	Water flow, water temperature	Increased flows create migration cues and improve downstream passage by decreasing water temperatures, increasing turbidity, and provide temporary access to more rearing habitat	Minor	Large	Low	Medium	Medium: Monitoring data shows juvenile movement during pulse flows

Action Component	Stressor/ Factor	Individual Response and Rationale of Effect	Severity of Stressor	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence
Channel Maintenance Pulse Flows	Water flow, stranding	Flow decreases following pulse flows may cause isolation and stranding, resulting in mortality. Down ramping rates will reduce magnitude	Sublethal to lethal	Small	Medium	Low	Medium
Channel Maintenance Pulse Flows	Water flow, habitat and prey availability	High flows provide temporary access to rearing habitat	Minor	Small	Medium	Medium	Medium
Ramp Down Rates	Stranding & Dewatering	Ramp down rates are expected to reduce stranding of juveniles	Minor	Large	Low	Medium	Low

Table 60. Central Valley spring-run Chinook salmon summary of primary affected life stages, primary stressors/effect pathways, and relevant management actions for seasonal operations periods. These are the elements that will be incorporated into the Integration and Synthesis section of the opinion.

Division/ Waterbody	Seasonal Operations Period	Affected Life Stage	Summary of Primary Stressors and Effects of the Proposed Action	Relevant Management Actions
Clear Creek	Summer Operations	Upstream Migration and Adult Holding	Water temperature ● Temperatures create temporary migration barriers at confluence in July and August ● Daily average holding Temperatures at Igo exceeded in critical years, which occur 16% of years	Seasonal temperature objectives
		Upstream Migration	Summer instream flows ● Impaired upstream migration conditions for late-arriving adults during July and August ● Pulse flows intended to create attraction flows for adults during spring months	Instream Flow Objectives, Pulse flows
		Juvenile Rearing	Water temperature ● Suboptimal temperature in lower 3 miles (>65°F)	Seasonal temperature objectives
		Juvenile Rearing	Stranding ● Juvenile stranding as flows recede affects small number of individuals	Ramping rates
	Fall Operations	Egg Incubation and Emergence	Water temperature ● Suboptimal temperatures in critical years may cause egg mortality and reduce production	Seasonal temperature objectives, pulse flows, and minimum instream flows
	Spring Operations	Adult and Juvenile Migration	Instream Flows ● Pulse flows provide adult attraction into holding habitat and cue juvenile out-migration	Pulse flows

Table 61. California Central Valley steelhead summary of primary affected life stages, primary stressors/effect pathways, and relevant management actions for seasonal operations periods. These are the elements that will be incorporated into the Integration and Synthesis section of the opinion.

Division/Water body	Seasonal Operations Period	Affected Life Stage	Summary of Primary Stressors and Effects of the Proposed Action	Relevant Management Actions
Clear Creek	Summer Operations	Upstream Migration	Water temperature ● Temperatures create temporary migration barriers at confluence in July and August	Seasonal temperature objectives
		Juvenile Rearing	Summer instream flows ● Summer flows may restrict the quantity and quality of rearing habitat	Instream Flow Objectives, Pulse flows
		Juvenile rearing	Water temperature ● Suboptimal temperature in lower 3 miles (>65°F)	Seasonal temperature objectives
		Juvenile Rearing	Stranding ● Juvenile stranding as flows recede affects small number of individuals	Ramping rates
	Fall Operations	Egg Incubation and Emergence	Water temperature ● Suboptimal temperatures in critical years may cause egg mortality and reduce production	Seasonal temperature objectives, pulse flows, and minimum instream flows
	Spring Operations	Adult and Juvenile Migration	Instream Flows ● Pulse flows provide adult attraction into holding habitat and cue juvenile out-migration	Pulse flows

7.2.2. Effects of the Action on Critical Habitat in Clear Creek

Clear Creek is within the designated critical habitat for CV spring-run Chinook salmon and CCV steelhead. The PBFs of designated critical habitat in Clear Creek include: (1) freshwater spawning sites, (2) freshwater rearing sites, and (3) freshwater migration corridors. As effects to individual fish are intrinsically linked to what life stage is present at the time of the exposure and condition of the habitat to support that life-stage, we use the species effects analysis conclusions (exposure and response, see Section 7.2.1.6), as the foundation for our analysis of effects to critical habitat. For example, as the effects of riparian removal on rearing juveniles are likely to result in reduced growth/survival, the effect to critical habitat would be described in terms of the PBFs affected for that life stage, thereby resulting in degraded rearing habitat. Table 62 for CV spring-run Chinook salmon and Table 63 for CCV steelhead summarize the effects of the proposed action on critical habitat.

7.2.2.1. Freshwater Spawning Sites

Warm water temperatures, low water flow, loss of natural river morphology and function, loss of floodplain habitat, and physical habitat alteration, are existing stressors that degrade the freshwater spawning habitat PBF for CV spring-run Chinook salmon eggs and adult CCV steelhead in Clear Creek. Spawning habitat for CV spring-run Chinook salmon is expected to be negatively impacted by elevated water temperatures because the proposed action spawning temperature objective (56°F) is suboptimal for Chinook salmon eggs (EPA 2003, Myrick and Cech 2004, Martin et al. 2017), and in some years, water temperatures are elevated above the spawning temperature objective. Elevated water temperatures occur more frequently in spawning habitat downstream of the Igo gauge.

The proposed variable instream flows provide adequate access to spawning sites for CV spring-run Chinook salmon and improved river flow for CCV steelhead adult migration and spawning sites, due to increased winter and spring flows. However, during summer and fall, lower flows prohibit the creation of channel complexity, degrading habitat availability. In critical water year types, minimum instream flows would be reduced even further, resulting in degradation of the freshwater spawning sites PBF including CV spring-run Chinook salmon or CCV steelhead redd dewatering.

Under the proposed action, both spring attraction and channel maintenance pulse flows are expected to support the spawning sites PBF (quality and quantity) by mobilizing and dispersing gravel and reducing fine sediment. In critical years, Reclamation will release up to 5,000 acre-feet for pulse flows and would not likely provide the magnitude needed for channel shaping, floodplain inundation, and improved ecological function of the channel (3,000 to 6,000 cfs), because releases are limited by the outlet capacity at Whiskeytown Dam (840 cfs). Pulse flows typically coincide with rain events, and less precipitation is expected during critical and dry water years. Although channel maintenance pulse flows are expected to support the freshwater spawning sites PBF in a low number of years, pulse flows are not expected to substantially benefit the freshwater spawning sites PBF because the magnitude and duration of the pulse flows are not expected to be great enough to shape the channel and adequately route spawning gravel.

7.2.2.2. Freshwater Rearing Sites for Juveniles

Warm water temperatures, low water flow, loss of natural river morphology and function, loss of floodplain habitat, and physical habitat alteration are stressors that degrade the freshwater rearing habitat PBF for juvenile CV spring-run Chinook salmon and CCV steelhead in Clear Creek. Currently, minimum instream flows provide water temperatures with constant, year-round flows that provide adequate access to rearing habitat. The proposed action's seasonally variable instream flows would improve the channel complexity needed for preferable rearing sites during winter and spring, which would lead to increased growth and provide refugia from predators. During summer and fall, decreased flows would reduce the amount of available habitat.

Channel maintenance pulse flows and spring-attraction pulse flows will increase flow variation, which will provide some geomorphic benefit that improves the quality and quantity of the freshwater rearing habitat PBF and increases the amount of rearing habitat for a short duration in the winter and spring months. While temporary, access to habitat with more complexity provides protection from predators and resources for increased growth and survival. Down ramping rates will be implemented, which will reduce stranding risk and minimize negative impacts on survival from flow decreases. Therefore, we expect minor impacts to rearing habitat PBFs as a result of the proposed action.

Water temperature management under the proposed action would provide suitable rearing habitat in all but the lowest section of Clear Creek. Water temperatures in the lower watershed are expected to be warm and suboptimal for rearing and growth in the summer months, which degrades the rearing habitat PBF. Warmer temperatures in this rearing habitat is expected to increase the likelihood of predation by providing habitat more suitable for warm-water predatory fishes.

7.2.2.3. Freshwater Migration Corridors for Out-Migrating Juveniles and Migrating Adults

Warm water temperatures, low water flow, loss of natural river morphology and function, loss of floodplain habitat, and physical habitat alteration are existing stressors that degrade the freshwater migration corridor PBF for CV spring-run Chinook salmon and CCV steelhead in Clear Creek. Some of these stressors are also caused by the proposed action, including water temperatures, flows, and habitat conditions. The freshwater migration corridor PBF for adults and juveniles is expected to be adversely affected downstream of the Igo gauge from June through August under the proposed action due to water temperatures that may exceed optimal migration conditions.

Under current operations, daily average water temperatures exceed optimal holding temperatures in the summer downstream of the compliance point at Igo where adult CV spring-run Chinook salmon are located annually. Under the proposed action, water temperatures will likely continue to adversely affect CV spring-run Chinook salmon migratory habitat downstream of the Igo gauge resulting in pre-spawn mortality. Flows will increase and water temperatures will decrease during the fall temperature management and with the increasing minimum flows under the proposed action, improving the migration corridor PBF for both juvenile and adult CV spring-run Chinook salmon and CCV steelhead.

Higher flow releases during channel maintenance and spring attraction pulse flows will provide flow variation, increased turbidity, cover, and additional passage routes. These conditions are expected to temporarily improve the freshwater migration corridor PBF for CV spring-run Chinook salmon adults and juveniles and CCV steelhead juveniles. Pulse flows for channel maintenance and spring attraction will continue to provide improvement to the migratory corridor. However, pulse flows may also create stranding habitat during down ramping resulting in temporarily degraded migratory habitat.

Table 62. Summary of probable change in physical or biological features of Central Valley spring-run Chinook salmon designated critical habitat in Clear Creek.

Action Component	Physical or Biological Features Affected	Response	Magnitude of Effect	Weight of Evidence
Water temperature management (June - August)	Freshwater rearing sites	Exceedance of water temperature objectives downstream of Igo compliance point degrades juvenile rearing and adult holding habitat	Low	Medium
Water temperature management (June - August)	Freshwater migration corridors	Warm water may block upstream adult migration, or juvenile emigration near confluence	Medium	Medium
Water temperature management (September - November)	Freshwater spawning sites	Spawning temperature objective (56°F) is suboptimal and exceedance further degrades spawning habitat. Greatest impact to habitat downstream of Igo compliance point, and in critical water year types	Medium	Medium
Minimum instream flows	Freshwater spawning sites	Variable instream flows will provide lower flows in summer through September, overlapping with when spawning begins. In critical water year types, reduced base flows will degrade spawning habitat	Medium	Low
Minimum instream flows	Freshwater rearing sites	Variable flows are expected to improve rearing habitat quantity and complexity	Medium	Medium
Minimum instream flows	Freshwater migration corridors	Variable flows expected to create cues for juvenile emigration and adult migration and provide more habitat during winter/spring	Medium	Low
Spring attraction pulse flows	Freshwater spawning sites	Pulse flows mobilize and disperse some spawning gravel, and decrease fines, which can improve spawning habitat	Low	Low
Spring attraction pulse flows	Freshwater migration corridors	Pulse flows increase turbidity, decrease barriers, and increase passage routes	High	High

Action Component	Physical or Biological Features Affected	Response	Magnitude of Effect	Weight of Evidence
Spring attraction pulse flows	Freshwater rearing sites	Pulse flows mobilize some gravel to form new habitat, and will temporarily increase rearing habitat accessibility and prey availability	Low	Medium
Spring attraction pulse flows	Freshwater rearing sites	Ramp down following pulse flow create stranding habitat	Low	Low
Channel maintenance pulse flows	Freshwater spawning sites	Pulse flows mobilize and disperse some spawning gravel, and decrease fines, which can improve spawning habitat. Magnitude and duration are not likely to be great enough to shape the channel and adequately route spawning gravel and improve spawning habitat	Low	Medium
Channel maintenance pulse flows	Freshwater rearing sites	Pulse flows mobilize some gravel to form new habitat, and will temporarily increase rearing habitat availability. Magnitude, duration, and frequency is not likely to be great enough to shape the channel and inundate floodplains to improve or increase rearing habitat long-term	Low	Medium
Channel maintenance pulse flows	Freshwater rearing sites	Ramp down following pulse flow create stranding habitat	Low	Low
Channel maintenance pulse flows	Freshwater migration corridors	Pulse flows increase turbidity, decrease barriers, and increase passage routes	Low	Low

Table 63. Summary of probable change in physical or biological features of California Central Valley steelhead designated critical habitat in Clear Creek.

Action Component	Physical or Biological Features Affected	Response	Magnitude of Effect	Weight of Evidence
Water temperature management (June - August)	Freshwater rearing sites	Warm water temperatures downstream of temperature compliance point degrade juvenile rearing habitat	Low	Medium
Water temperature management (June - August)	Freshwater migration corridors	Warm water may block early migrating adults at confluence	Low	Medium
Water temperature management (September - November)	Freshwater migration corridors	Decreased temperatures may improve conditions for migration	Low	Low

Action Component	Physical or Biological Features Affected	Response	Magnitude of Effect	Weight of Evidence
Water temperature management (September - November)	Freshwater rearing sites	Extending the 56°F temperature objective into November may improve conditions for rearing yearlings	Low	Low
Minimum instream flows	Freshwater spawning sites	Variable flows improve habitat complexity except in critical water year types when reduced base flows will degrade spawning habitat	Low	Low
Minimum instream flows	Freshwater rearing sites	Variable flows improve habitat and prey availability, except in critical water years when reduced base flows result in reduced available rearing habitat	High	Medium
Minimum instream flows	Freshwater migration corridors	Variable flows may create cues for juvenile emigration and adult migration, except in critical water year types	High	Medium
Spring attraction pulse flows	Freshwater spawning sites	Pulse flows mobilize and disperse some spawning gravel, and decrease fines, which can improve spawning habitat	Low	Low
Spring attraction pulse flows	Freshwater migration corridors	Pulse flows increase turbidity, decrease barriers, and increase passage routes	Medium	Low
Spring attraction pulse flows	Freshwater rearing sites	Pulse flows mobilize some gravel to form new habitat, and will temporarily increase rearing habitat accessibility and prey availability	Low	Medium
Spring attraction pulse flows	Freshwater rearing sites	Ramp down following pulse flow create stranding habitat	Low	Low
Channel maintenance pulse flows	Freshwater spawning sites	Pulse flows mobilize and disperse some spawning gravel, and decrease fines, which can improve spawning habitat. Magnitude and duration are not likely to be great enough to shape the channel and adequately route spawning gravel and improve spawning habitat	Low	Medium
Channel maintenance pulse flows	Freshwater rearing sites	Pulse flows mobilize some gravel to form new habitat, and will temporarily increase rearing habitat availability. Magnitude, duration, and frequency is not likely to be great enough to shape the channel and inundate floodplains to improve or increase rearing habitat long-term	Low	Medium
Channel maintenance pulse flows	Freshwater rearing sites	Ramp down following pulse flow create stranding habitat	Low	Low

Action Component	Physical or Biological Features Affected	Response	Magnitude of Effect	Weight of Evidence
Channel maintenance pulse flows	Freshwater migration corridors	Pulse flows increase turbidity, decrease barriers, and increase passage routes	Low	Low

7.3. American River Division

7.3.1. Effects of the Action on Species

Reclamation operates and maintains the American River Division of the CVP for flood control, municipal, industrial and agricultural water supplies, hydroelectric power generation, fish and wildlife protection, recreation, and Delta water quality. Facilities include Folsom Dam, its reservoir (977 TAF capacity), power plant, temperature control shutters on the power plant, and the Joint Federal Project auxiliary spillway, as well as the Nimbus Dam, Lake Natoma, Nimbus Power Plant, and Folsom South Canal. The CVP additionally delivers water to the Freeport Regional Water Project Intake. Releases from Folsom Dam are re-regulated approximately 7 miles downstream by Nimbus Dam. Nimbus Dam creates Lake Natoma, which serves as a forebay for diversions to the Folsom South Canal and the Nimbus Fish Hatchery. Water diverted to the fish hatchery returns to the American River through four outfalls approximately 0.5 miles downstream of Nimbus Dam. Releases from Nimbus Dam to the American River pass through the Nimbus Power Plant or the spillway gates at flows of more than 5,000 cfs. Folsom Reservoir is the main storage and flood control reservoir on the American River. Numerous other smaller non-CVP and SWP reservoirs in the upper basin provide hydroelectric generation and water supply without specific flood control responsibilities. Anadromous fishes of the American River are relegated to the lower 23 miles of the river and nearly all the historical CCV steelhead spawning and rearing habitat of the American River is inaccessible, located upstream of Nimbus Dam.

Figure 85 displays a map of the American River Division and Figure 86 depicts the deconstructed action describing how the proposed action components relate to each other. Table 64 identifies the primary stressors influenced by each proposed action component. Descriptions of each stressor, including the way in which the stressors would affect an individual's fitness, are then discussed. The exposure and response of each species to the project-related stressors are then analyzed in the following sections for each proposed action component.

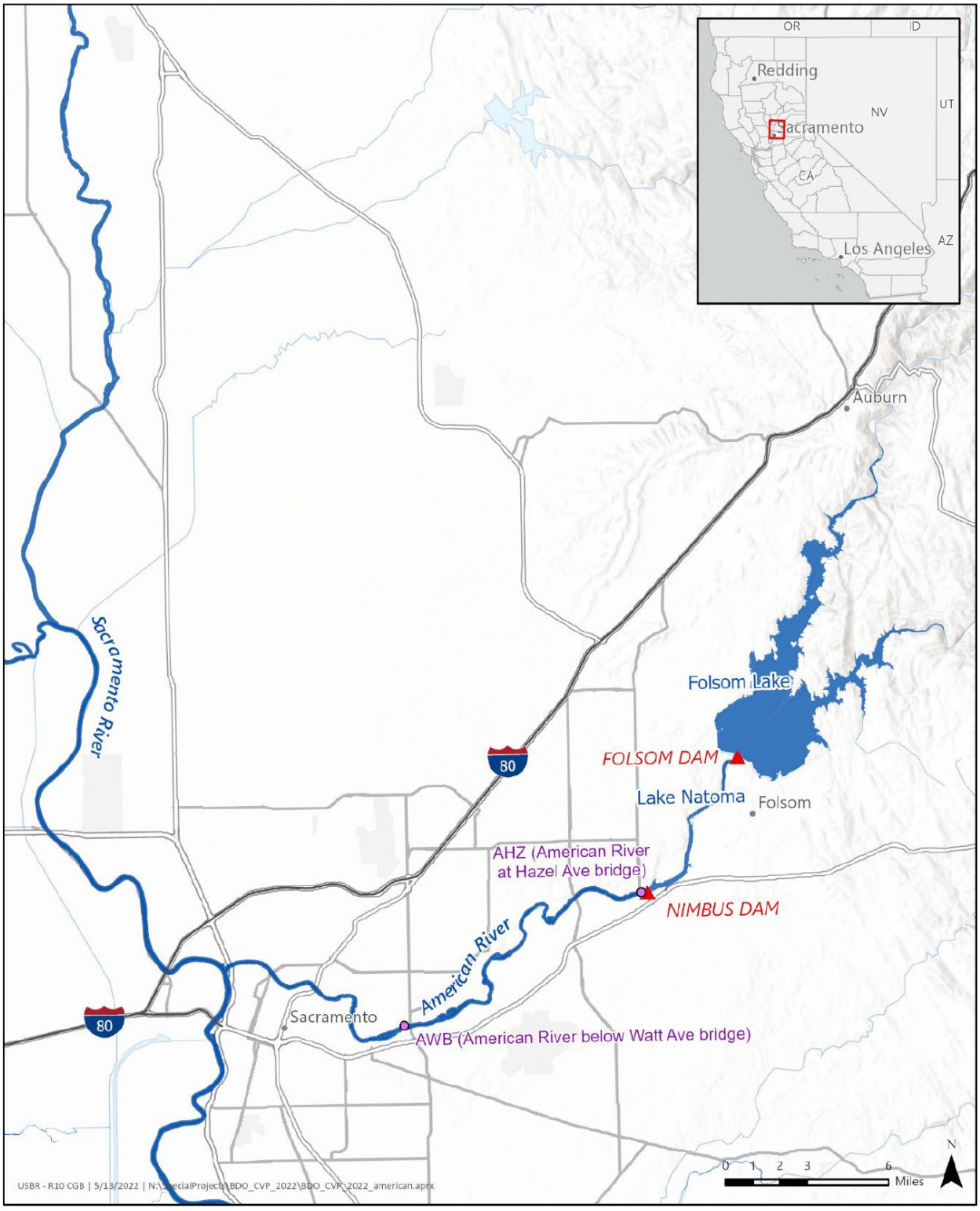


Figure 85. Facilities in the American River Division of the Central Valley Project.

Source: Figure 3-5 in (U.S. Bureau of Reclamation 2023-2024)

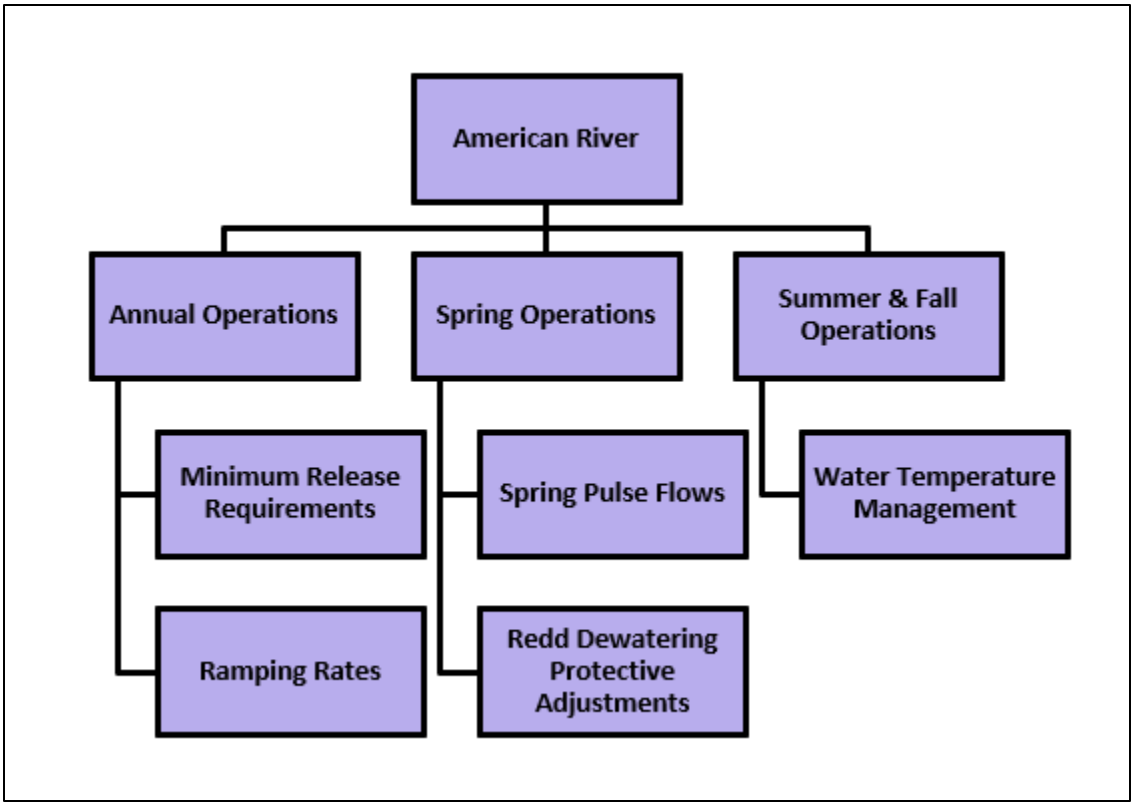


Figure 86. Deconstructed action describing the relation of project components in the American River.

Table 64. Primary stressors in the American River Division on California Central Valley steelhead influenced by each proposed action component.

Stressor	Water temperature and dissolved oxygen	Spawning habitat	Redd Quality	Stranding Risk and Redd Dewatering	Refuge habitat and Food availability and quality	Out-migration cues	Pathogens and Disease
Flow Management		X		X	X		
Minimum Release Requirements and Redd Dewatering Protective Adjustments	X	X	X	X	X	X	X
Ramping Rates		X		X	X		
Spring Pulse Flows						X	
Water Temperature Management	X	X	X		X	X	X

7.3.1.1. Conceptual Models and Stressor Linkages

This introduction section describes how we have deconstructed the proposed action into stressors that affect CCV steelhead and its critical habitat, the only ESA-listed species that spawns within the American River. It also describes how we have assessed CCV steelhead exposure and response to proposed action-related stressors.

Although the American River is not critical habitat for SR winter-run Chinook salmon and no targeted monitoring occurs for them in these habitats (Johnson et al. 2017), genetic research indicates their presence (Pacific States Marine Fisheries Commission 2023), and isotope analyses of otoliths from 2007 to 2009 revealed that an average of 21 percent of adults had reared in the American River (Phillis et al. 2018). These adult SR winter-run Chinook salmon otoliths were collected from the Livingston Stone National Fish Hatchery and represented about 1 percent of the total population and about 50 to 85 percent of the SR winter-run Chinook salmon spawned at the hatchery. Similarly, juvenile CV spring-run Chinook salmon, along with SR winter-run Chinook salmon, have been observed at the rotary screw trap downstream of Watt Avenue on the Lower American River (Pacific States Marine Fisheries Commission 2023). This sampling genetically confirmed 156 juvenile SR winter-run Chinook salmon and 44 juvenile CV spring-run Chinook salmon from 2015 to 2023. However, the timing and location of this non-natal rearing are not well understood; therefore, CV spring-run Chinook salmon and SR winter-run Chinook salmon are not included in the American River effects analysis.

Southern DPS green sturgeon are also potentially present in the American River. While there is no acoustic data to confirm their presence, this could be due to a lack of monitoring availability. The mouth of the American River provides suitable foraging and holding habitat for sDPS green sturgeon, and it is possible that juvenile sDPS green sturgeon could access the American River, as they do on the Feather and Yuba rivers to the north. Additionally, given the right temperature and flow conditions, combined with suitable fine sediment for spawning, it is plausible that sDPS green sturgeon could have historically utilized the upper areas of the American River for spawning. The presence of invertebrates and submerged aquatic vegetation in the American River provides potential foraging habitat for both juvenile and adult sDPS green sturgeon. Overall, the available evidence suggests that sDPS green sturgeon are potentially present in the American River, although more research is needed to confirm their presence and understand their habitat use. In sum, the best available science indicates the potential, but does not confirm the presence of sDPS green sturgeon in the American River. Therefore, the species is not included in this effects analysis.

Naturally-produced CCV steelhead in the Lower American River are affected by many different stressors, which, for the purpose of this analysis, are categorized into two groups based on whether they do, or do not, result from CVP operations. The Environmental Baseline section characterizes those stressors that are not the result of CVP operations, although CVP operations may exacerbate the effect of the stressor. An example of a stressor that is exacerbated by CVP operations is predation. CCV steelhead co-evolved with predators such as pikeminnow, but exposure to both elevated water temperatures and limited flow-dependent habitat availability resulting from CVP operations make juvenile CCV steelhead more susceptible to predation (Bratovich et al. 2005, Water Forum 2005).

A few steps are followed to assess CCV steelhead exposure. First, the CCV steelhead life stages and associated timings are identified. Adult CCV steelhead immigration in the American River

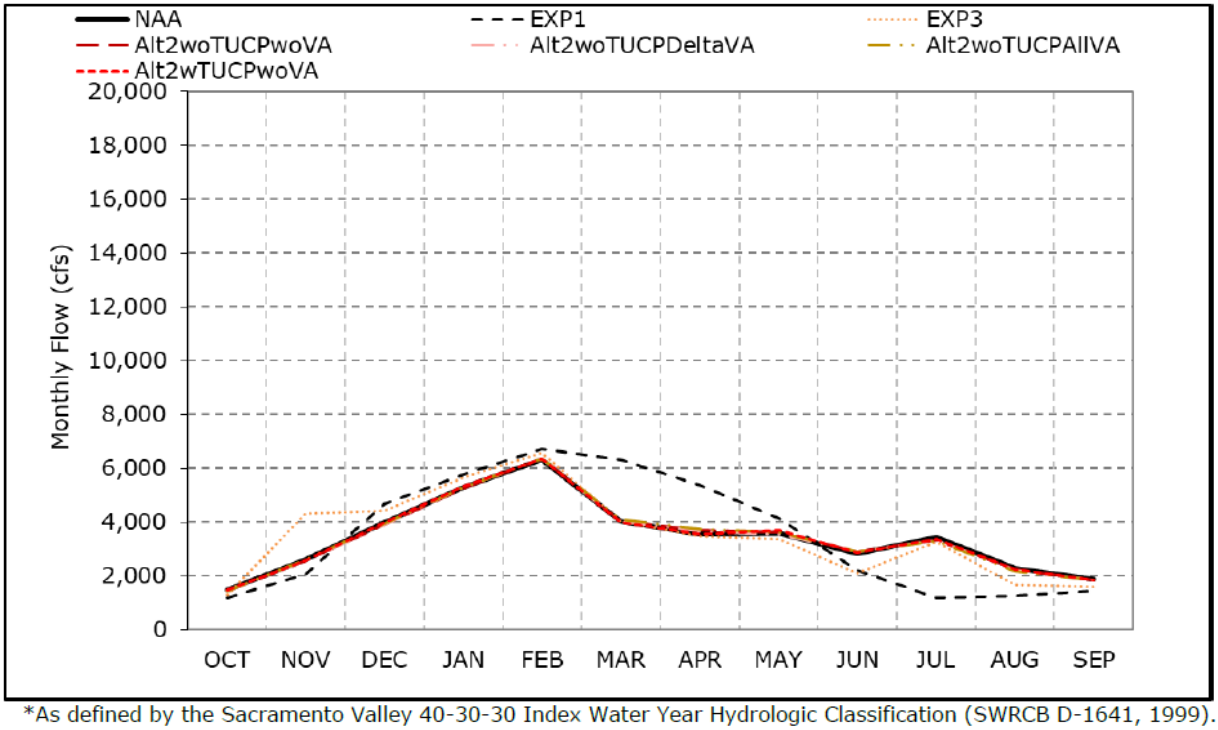
generally occurs from September through April with a peak occurring from December through March (Surface Water Resources Inc. 2001). Spawning reportedly occurs in late December to early April, with the peak occurring in late February to early March (Hannon and Deason 2008). The embryo incubation life stage begins with the onset of spawning in late December and generally extends through May, although, in some years incubation can occur into June (Surface Water Resources Inc. 2001). Juvenile CCV steelhead typically rear in the American River for a year or more before emigrating as smolts from January through June (Surface Water Resources Inc. 2001).

Second, the spatial distribution of each life stage is identified. The CCV steelhead immigration life stage occurs throughout the entire Lower American River, with adults holding from approximately river mile 5 to Nimbus Dam at river mile 23 (Hannon and Deason 2008). Approximately 90 percent of spawning occurs upstream of Watt Avenue located near river mile 9.4 (Hannon and Deason 2008). The juvenile life stage occurs throughout the entire river, with rearing generally occurring in the vicinity of the upstream areas used for spawning. Most juvenile CCV steelhead are believed to migrate through the lower sections of the American River into the Sacramento River as smolts.

Last, the temporal and spatial distributions of proposed action-related stressors are overlaid on top of the temporal and spatial distributions of Lower American River CCV steelhead. This overlay represents the completed exposure analysis and is described in the first three columns of Table 72. Unless otherwise specified in Table 72, the temporal and spatial distributions of proposed action-related stressors are the same as the temporal and spatial distributions of CCV steelhead life stages as specified in Table 72.

Once the exposure of Lower American River CCV steelhead to the proposed action has been described, the next step is to assess how these fish are likely to respond to the proposed action-related stressors. In general, responses to stressors fall on a continuum from slight behavioral modifications to death. Life stage-specific responses to specific stressors related to the proposed action are described in detail in the following sections and are summarized in Table 72. There may be other project stressors acting on Lower American River CCV steelhead than those identified in Table 72. However, this effects analysis intends to identify and describe the most important project-related stressors to these fish. The stressors from the project components are organized based on the SAIL conceptual models (Windell et al. 2017), as previously described in the Sacramento River Division Conceptual Model and Stressor Linkages.

The BA includes modeling results for several operational scenarios; this effects analysis primarily uses results from the NAA, the proposed action (Alt2v1) without TUCPs, and EXP3. The pre-adoption period of the Delta VAs, which is a 2-year volumetric export reduction per the Voluntary Agreements (scenario: Alt2v2), has an initial 2-year time limit and is not reasonably certain to occur for the duration of the proposed action. Analysis of the effects of the Alt2v2 scenario did not show substantial differences in flow and temperature for the American River Division, such that modeling for all of the Alt2 scenarios are virtually indistinguishable outside of the Delta (see Figure 87 and Figure 88). Therefore, the effects of the proposed action, commonly referred to as Alt2woTUCPwoVA in the model results for scenario Alt2v1, are presented



*As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).
*Water Year Types results are displayed with calendar year – year type sorting.
*All scenarios are simulated at 2022 Median climate condition and 15 cm sea level rise.

Figure 87. American River below Nimbus Dam Flow, Long-Term Average Flow (cubic feet per second).

Source: Figure F.2.2-12-1 in (U.S. Bureau of Reclamation 2023-2024)

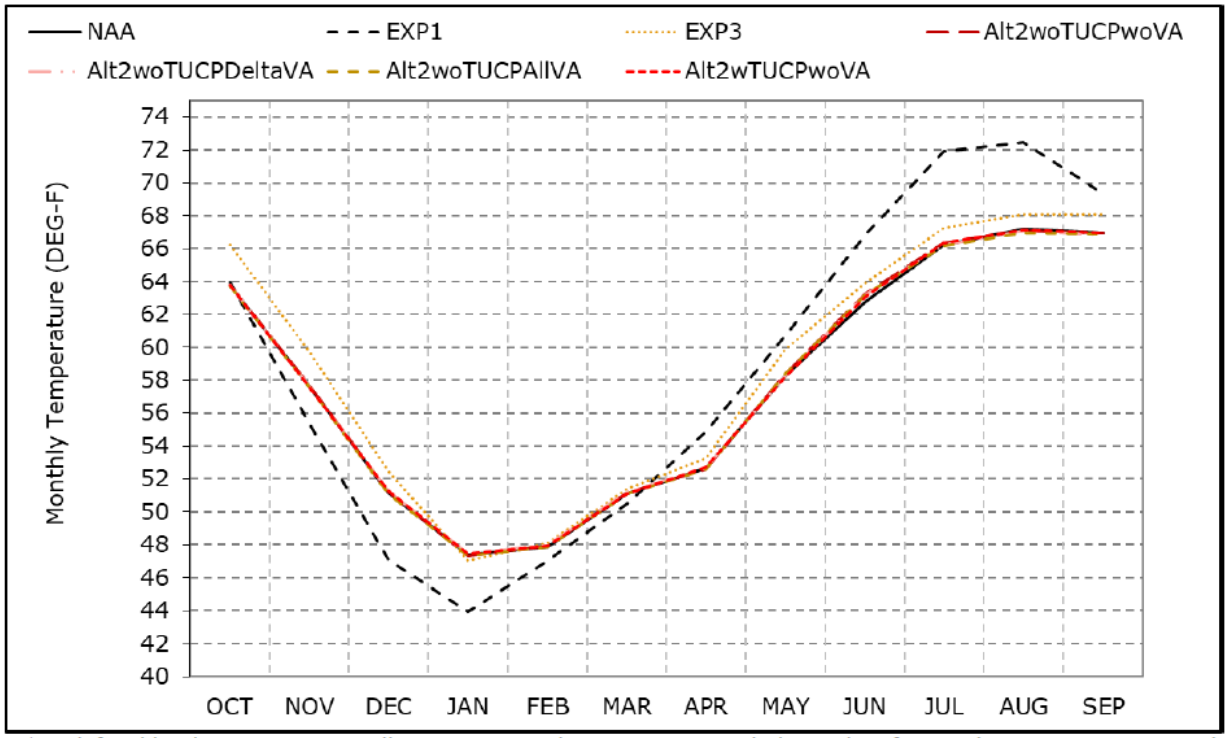


Figure 88. American River below Nimbus Dam, long-term average temperature.

Source: Figure F.2.11-13-1 in (U.S. Bureau of Reclamation 2023-2024)

Releases from Nimbus Dam to the American River affect the quantity and quality of CCV steelhead habitat (Snider et al. 2001, Water Forum 2005), water quality, and water temperature (State Water Resources Control Board 1999, Kimmerer and Nobriga 2008). Water temperature is perhaps the physical factor with the greatest influence on the American River CCV steelhead population. Water temperature directly affects survival, growth rates, distribution, and developmental rates. Water temperature also secondarily affects growth rates, disease incidence, predation, and long-term survival (McCullough 1999). Water temperatures in a regulated river can be a function of river distance, environmental heat flux, and the timing, volume, and temperature of water being released from upstream dams (Daniels and Danner 2020). Thus, water temperatures in the Lower American River are influenced by proposed action operations. Secondarily, water temperatures in the Lower American River can be influenced by the effect of precipitation patterns and climate on storage volume and water temperatures in Folsom Reservoir.

As for other division analyses, NMFS used modeled temperatures provided in the BA to evaluate the suitability of water temperature conditions for salmonids under the proposed action. Recent daily water temperature data from the Lower American River are used to provide context for temperature scenarios that CCV steelhead could be exposed to under the proposed action. Recent water temperature data from the Lower American River may be a better indicator of the daily

temperature patterns that CCV steelhead will be exposed to under the proposed action than the modeled water temperature results, which have a monthly time step.

7.3.1.2. American River Division Project Components Analysis

7.3.1.2.1. Folsom Annual Operations

Reclamation manages Folsom Reservoir throughout the year to balance flood control, deliver water to users, maintain healthy water flow levels in the river and Delta for ecosystems, and ensure good water quality in the Delta. Facilities include Folsom Dam, its reservoir (977 TAF capacity), power plant, temperature control shutters on the power plant, and the Joint Federal Project auxiliary spillway, as well as the Nimbus Dam, Lake Natoma, Nimbus Power Plant, and Folsom South Canal. The CVP additionally delivers water to the Freeport Regional Water Project Intake. Releases from Folsom Dam are re-regulated approximately 7 miles downstream by Nimbus Dam. Nimbus Dam creates Lake Natoma, which serves as a forebay for diversions to the Folsom South Canal and the Nimbus Fish Hatchery. Water diverted to the fish hatchery returns to the American River through four outfalls approximately 0.5 miles downstream of Nimbus Dam. Releases from Nimbus Dam to the American River pass through the Nimbus Power Plant or the spillway gates at flows more than 5,000 cfs.

Reclamation's American River operations include the American River Minimum Flow Schedule (ARMFS) which is intended to provide water supply reliability and water temperature management for fisheries. The ARMFS uses two hydrological indices to determine Reclamation's Minimum Release Requirement (MRR) from Nimbus Dam. The Sacramento River Index (SRI), a monthly forecast of the total unimpaired water year flow volume for key rivers in the region, is used to determine the January MRR. From February to December, the American River Index (ARI) is used to determine the MRRs. The ARI measures the unimpaired inflow to Folsom Reservoir minus certain spilled water. The MRR curves are based on inflection points, and corresponding index values are determined through an iterative process, while target flows are established based on biological considerations. Each curve is tailored by Reclamation to specific conditions and biological needs. After the initial release of Bulletin 120 (California Department of Water Resources 2024a; a DWR forecast of the volume of seasonal runoff from the watershed including precipitation, snowpack, reservoir storage, and runoff) in February and subsequent monthly updates, MRRs can be calculated through December. The final MRR calculations for the remainder of the year are finalized in May. The ARMFS also incorporates Redd Dewatering Protective Adjustments (RDPA) to safeguard the spawning habitats of fall-run Chinook salmon and CCV steelhead from redd dewatering due to reductions in MRR. Therefore, multiple MRRs are considered during certain months: the SRI-based MRR in January, the ARI-based MRR from February to December, and the RDPA-based MRRs for fall-run Chinook salmon redds in January and February and for CCV steelhead redds in February through May. The RDPAs act as a safeguard by potentially limiting MRR decreases between December and June, although it does not impact releases exceeding the MRR. Except in January, the highest of the MRRs each month control operations.

Winter operations most often prioritize flood control and the preservation of minimum flow levels for the American River and the Delta. Flood control may drive operations in wetter years and is guided by the rules for dam safety and flood risk management in the U.S. Army Corps of Engineers (2019). Conversely, when flood risks are minimal, Reclamation proposes to store

Folsom Reservoir inflows that exceed releases for minimum instream flows and Delta water quality requirements. Reclamation attempts to stabilize releases to minimize potential redd dewatering, redd scouring, and juvenile stranding for CCV steelhead and fall-run Chinook salmon, but Delta outflow requirements may require increased releases.

Spring operations focus on maximizing reservoir storage capacity by capturing spring snowmelt runoff. Water releases are also managed to create suitable conditions for juvenile salmonids. The ARMFS includes both minimum releases and, in some years, a pulse flow to cue juvenile salmonids to emigrate. Folsom Reservoir, as the closest CVP reservoir to the Delta, may also be called upon to increase releases to meet Delta water quality requirements under SWRCB D-1641, which is included in the regulatory standards used for the CalSim modeling. Folsom Reservoir storage typically reaches its annual minimum by September due to summer water releases and diversions. The uncertainty of winter weather forecasts makes predicting spring inflow, and summer storage, a challenge. Reclamation considers an end-of-December Folsom Reservoir storage of at least 300 TAF for operational forecasts, but if the May forecast does not anticipate meeting that target, it is reported to the American River Group and potential actions are formulated. This proactive approach aims to establish a more reliable cold water reserve, ensuring the ability to manage downstream river temperatures throughout the critical summer and fall seasons. Increased storage can help maintain suitable water temperatures in the Lower American River for salmonids and ensure reliable water deliveries to American River water agencies.

During the summer months, Reclamation releases water exceeding minimum flow requirements to address three key objectives: instream temperature control, Delta outflow, and water supply. The volume of water released and the depth from which it is drawn (shutter elevations) are strategically adjusted based on weather forecasts. This balancing tries to ensure that sufficient cold water remains available later in the season for fall-run Chinook salmon, while also keeping the Lower American River cool enough for CCV steelhead during the hot summer.

Fall operations at Folsom Reservoir prioritize maintaining suitable water temperatures for both CCV steelhead and fall-run Chinook salmon. Due to limited cold water reserves and storage capacity, releases and shutter operations are adjusted to maintain suitable temperatures for CCV steelhead rearing and fall-run Chinook salmon spawning. Ideally, Reclamation aims to reduce MRRs as soon as possible in the fall. Maintaining stable flows throughout the fall-run Chinook salmon spawning and egg incubation period helps minimize redd dewatering and juvenile stranding.

American River operations are largely managed by Reclamation through Governance, which includes two main coordination forums that will meet regularly to discuss seasonal and real-time operations. These include the Water Operations Management Team (WOMT) and the American River Group. The American River Group is a technical group that discusses reservoir and storage planning, forecasting and seasonal operations, flow and water temperature management, and monitoring programs. American River Governance will use a collaborative approach to planning and decision-making. For each specific seasonal action component, Reclamation will request NMFS, USFWS, and CDFW to provide technical assistance along with the other members through these groups. Governance describes that the groups will strive to reach consensus; if consensus cannot be reached, group members may elevate to the next higher level for resolution. Agency directors may reserve final decision making for matters under their respective authority.

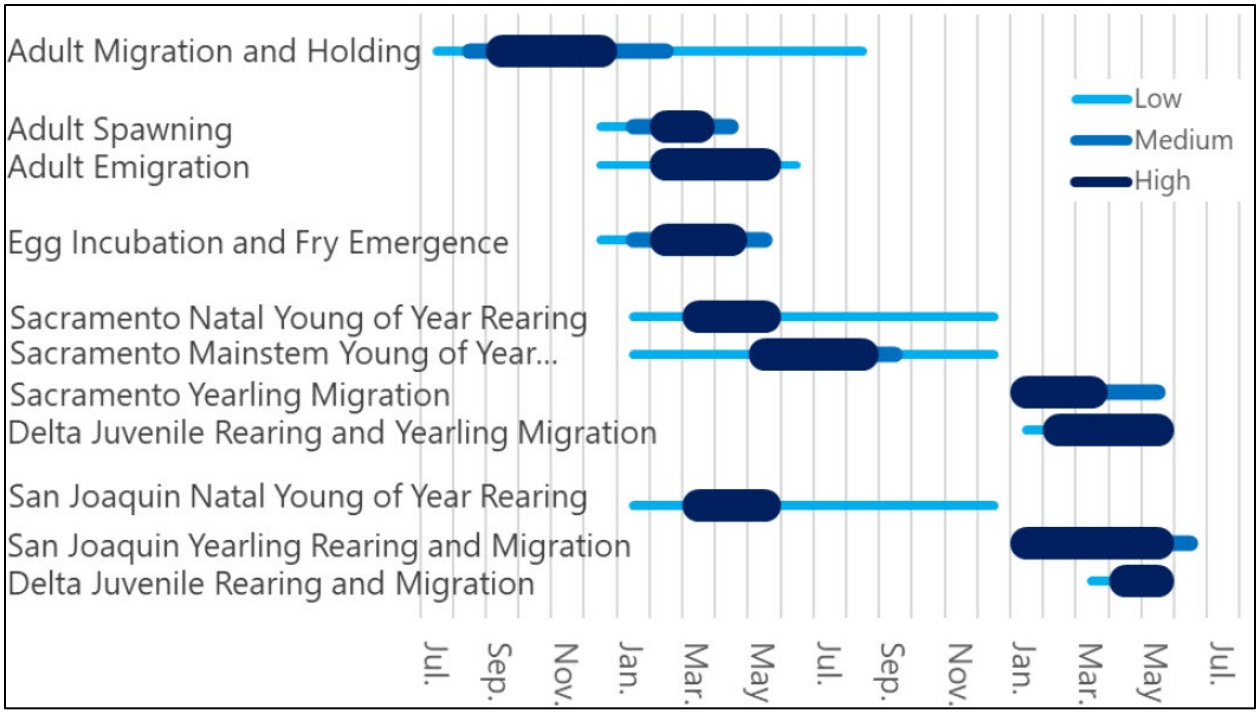


Figure 89. Generalized temporal life stage domains for California Central Valley steelhead.

Source: Figure 16 in (U.S. Bureau of Reclamation 2023-2024)

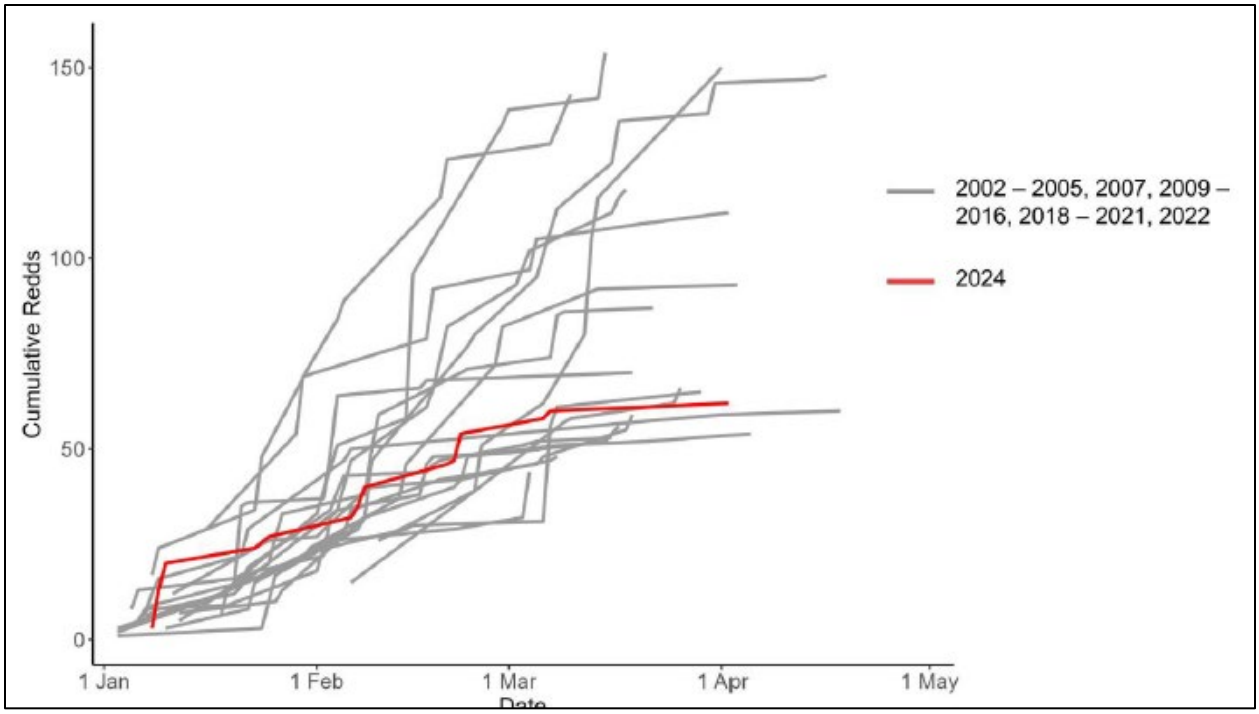


Figure 90. Lower American River cumulative number of steelhead redd observations, 2002–2024. Note that surveys were not performed in 2006 and 2008 due to poor visibility, and data from 2017 and 2023 is not included due to incomplete data from high flows and low visibility conditions.

Source: Figure 15 in (Sweeney and Hannon 2024)

Adult CCV steelhead typically migrate into Central Valley streams starting in August, peaking in January and February, and potentially occurring year-round (Figure 89). Spawning primarily takes place from December to April, and on the American River is concentrated from January through March (Figure 90). CCV steelhead spawning in the Lower American River appears to concentrate in side channels during high-flow years, likely due to a combination of habitat preference and increased difficulty in detecting redds in deeper main channels. For example, approximately 65 percent of all CCV steelhead redds in 2024 were observed in, or associated with, side channel habitat, a dynamic also observed during previous high flow years when spawning activity could still be observed (e.g., 2023, 2017, and 2011). This pattern may also be partly driven by observation bias as it is more difficult to visually observe the river bed and identify redds at higher flows (Sweeney and Hannon 2024). On average (from 2002 to 2024, with data gaps in 2006 and 2008), the highest density of redds per mile on the Lower American River is found from Nimbus Dam to Ancil Hoffman Park (river miles 23 to 17, Table 4 in (Sweeney and Hannon 2024). After hatching, eggs incubate in the gravel for 4 to 6 weeks. Juvenile CCV steelhead rear and migrate downstream, primarily from January to June, though this can occur year-round due to varying freshwater residence times. The effects of annual operations are deconstructed into the project components and analyzed in the sections below followed by a summary.

7.3.1.2.2. Flow Management

7.3.1.2.2.1. Minimum Release Requirements and Redd Dewatering Protective Adjustments

Minimum Release Requirements from Nimbus Dam aim to maintain adequate flow levels in the Lower American River to protect fish populations and their habitats. Reclamation proposes to adopt the ARMFS, which builds upon the 2017 Modified Flow Management Standard. The ARMFS establishes MRRs ranging from 500 to 2,000 cfs, varying by season and annual hydrology, to provide suitable conditions for CCV steelhead and fall-run Chinook salmon (Table 65 and Table 66). Notably, the MRR for January will be determined using the SRI, while the ARI will be used for the remaining months, both with a 90-percent exceedance forecast. These indices will be based on the first Bulletin 120 of each year, in February, then updated with each subsequent month's Bulletin 120, until a final MRR is calculated in May for the remainder of the year. Reclamation will continue to collaborate with the American River Group to shape upcoming releases within operational limitations. Key differences between the ARMFS and the Modified Flow Management Standard include using a 90-percent exceedance forecast for MRR calculations instead of 50 percent or 75 percent, establishing a defined timeframe for implementing monthly MRRs, evaluating and potentially adjusting MRR calculations in November and December, and removing the offramp and volume offset in the spring pulse flow to provide more flexibility for flow shaping.

Table 65. Summary of the Minimum Release Requirements (MRR) in the American River Minimum Flow Schedule (ARMFS) with Sacramento River Index (SRI) and American River Index (ARI) above (January - December). SRI (Sacramento River Index) and ARI (American River Index) and ARI (American River Index) are measured in TAF (thousand acre-feet).

	Sacramento River Index (SRI)		American River Index (ARI)	
January	SRI <= 5,500 5,500 TAF < SRI <= 7,800 7,800 TAF < SRI <= 11,500 SRI > 11,500	MRR = 500 MRR = 0.1304 * SRI -217 MRR = 0.2568 * SRI -1,203 MRR = 1,750		
February			ARI <= 800	MRR = 500
March			800 TAF < ARI <= 1,000 1,000 TAF < ARI <= 1,958 ARI > 1,958	MRR = 1.500 * ARI -700 MRR = 0.9918 * ARI -192 MRR = 1,750
April			ARI <= 800	MRR = 500
May			800 TAF < ARI <= 1,000 1,000 TAF < ARI <= 2,210	MRR = 1.500 * ARI -700 MRR = 0.579 * ARI + 221
June			ARI > 2,210 TAF	MRR = 1,500
July			ARI <= 800	MRR = 500
August			800 TAF < ARI <= 1,000	MRR = 1.500 * ARI -700

	Sacramento River Index (SRI)	American River Index (ARI)	
September		1,000 TAF < ARI <= 1,200 1,200 TAF < ARI <= 1,958 ARI > 1,958 TAF	MRR = 3.5 * ARI -2,700 MRR = 0.330 * ARI + 1,104 MRR = 1,750
October		ARI <= 800 800 TAF < ARI <= 1,500 1,500 TAF < ARI <= 1,914 ARI > 1,705	MRR = 500 MRR = 0.429 * ARI +157 MRR = 1.690 * ARI -1,735 MRR = 1,500
November		ARI <= 800 800 TAF < ARI <= 1,500	MRR = 500 MRR = 0.429 * ARI +157
December		1,500 TAF < ARI <= 2,210 ARI > 2,210	MRR = 1.690 * ARI -1,735 MRR = 2,000

Source: (U.S. Bureau of Reclamation 2023-2024)

Table 66. Summary of the Redd Dewatering Protective Adjustments (RDPA) below (January - May). MRR (Minimum Release Requirement) is measured in cfs.

	Redd Dewatering Protective Adjustments (RDPA)	
	Fall-Run Chinook Salmon	**Steelhead**
January	≥70% & ≤100% of the December MRR	
February	≥70% of the December MRR	Cannot be less than the minimum flow in Table 3-5 of the proposed action (Reclamation 2023-2024), based on the January MRR.
March - May		Cannot be less than the minimum flow in Table 3-5 of the proposed action (Reclamation 2023-2024), based on the January or February MRR, whichever is greater.

Source: (U.S. Bureau of Reclamation 2023-2024)

Although the MRRs are initially established, releases from Folsom Reservoir are made, in part, for flood control and to meet Delta water quality objectives and demands. These operations can result in release events during the winter and spring that are characterized by rapid flow increases for a period followed by rapid flow decreases. Releases from Folsom Dam are re-regulated approximately 7 miles downstream by Nimbus Dam. Reclamation operates for flood control in accordance with the U.S. Army Corps of Engineers (2019). The proposed action does not propose changes to flood control operations from the current water control manual; therefore, these impacts from releasing high flow events would be consistent between NAA and the proposed action.

Reclamation and USACE constructed a new spillway (completed in 2017), known as the Joint Federal Project, which allows Reclamation to make releases for flood control at lower elevations than the original spillway, but at significantly higher elevations than the river outlets. Use of the Joint Federal Project allows for more stable high flows during storm events by allowing lower release volumes to occur sooner and have a longer duration but with lowered peak flow. Additionally, the use of the Joint Federal Project should improve the cold water pool volume by avoiding releases through the river outlet tubes which draw from a colder elevation. The Water Control Manual that accompanies this new facility has undergone separate ESA consultation with the USACE as the federal action agency (National Marine Fisheries Service 2018a); therefore, implementation of the Water Control Manual is in the environmental baseline for this consultation.

7.3.1.2.2.2. Ramping Rates

Rapid fluctuations in river levels, caused by adjusting reservoir release rates, can significantly affect aquatic life. Abrupt reductions in flow may leave fish and macroinvertebrates stranded. Implementing controlled ramping rates, which limit the rate at which releases are decreased, can mitigate or potentially eliminate these adverse effects. Reclamation proposes to ramp down releases in the American River below Nimbus Dam, as shown in Table 67. Reclamation proposes to ramp down releases in the American River below Nimbus Dam at night, if possible. The maximum allowable decrease within a 24-hour period (ranging from 500 to 4,000 cfs) and the maximum change per step (from 100 to 1,350 cfs) vary depending on the starting flow rate (specified in ten bins from <5,000 to 20,000). As the flow rate decreases, so do the allowable changes, reflecting a more cautious approach at lower flows to minimize impacts on aquatic life. Specifically, daily decreases of 10 percent or less are allowed under the lowest flow conditions (e.g., 500 out of 5,000 cfs), but that percentage can be as high as 25 percent (4,000 out of 16,000 cfs) at the upper end. In practice, Reclamation usually decreases releases using a step duration of not less than 4 hours, but in some circumstances, shorter step durations are implemented. During flood control operations, Reclamation may deviate from these ramping requirements. In coordination with the American River Group, Reclamation may also establish faster down-ramping rates on a case-by-case basis for essential monitoring or maintenance activities.

Table 67. American River ramping rates in cubic feet per second (cfs).

Source: (U.S. Bureau of Reclamation 2023-2024)

Lower American River Daily Rate of Change (cfs)	Amount of Decrease in 24 Hours (cfs)	Maximum Change per Step (cfs)
20,000 to 16,000	4000	1350
16,000 to 13,000	3000	1000
13,000 to 11,000	2000	700

Lower American River Daily Rate of Change (cfs)	Amount of Decrease in 24 Hours (cfs)	Maximum Change per Step (cfs)
11,000 to 9,500	1500	500
9,500 to 8,300	1200	400
8,300 to 7,300	1000	350
7,300 to 6,400	900	300
6,400 to 5,650	750	250
5,650 to 5,000	650	250
<5,000	500	100

7.3.1.2.2.3. Spring Pulse Flows

A spring pulse flow in the American River potentially benefits CCV steelhead by stimulating downstream migration and enhancing juvenile survival rates. The pulse flow also scours and diversifies habitats for spawning and rearing, while increasing nutrient and food transport, benefiting the entire aquatic ecosystem. This ultimately contributes to the health and resilience of CCV steelhead populations in the river. Reclamation will implement a spring pulse flow when the March MMR falls between 1,000 and 1,500 cfs. This pulse flow will peak at three times the March MRR, not exceeding 4,000 cfs, and last for 2 days. Subsequently, releases will be decreased by a maximum of 500 cfs per day and 100 cfs per hour, preferably at night. The American River Group will provide technical input on flow volumes, while the final timing will be determined collaboratively by CDFW, USFWS, and NMFS. Reclamation, through the American River Group, may facilitate additional pulse flows if water is available from non-CVP sources or if release schedules allow for greater flexibility.

7.3.1.2.2.4. California Central Valley Steelhead Exposure and Response

The exposure and response of CCV steelhead to American River flow management under the proposed action are analyzed below.

7.3.1.2.2.4.1. Exposure (Life Stage Location and Timing)

CCV steelhead express a diverse array of life history strategies, including both anadromous and resident (i.e., rainbow trout) life histories. Anadromous and resident life histories can be adopted by individuals from the same sibling cohort, making determinations regarding run timing

difficult. The American River historically supported both native and introduced CCV steelhead runs. Native CCV steelhead were likely a mix of winter- and spring-run fish, with adults entering the river from November to May and spawning from February to June. However, the current population is primarily composed of hatchery-raised winter-run CCV steelhead that spawn in the spring (California Department of Fish and Game 1991, Brodsky et al. 2020). For this analysis, CCV steelhead adult migration and holding and spawning were considered from November through April, with spawning and egg incubation beginning in December, and the former running through April with the latter running through June. This period also coincides with kelt emigration, from December through June, while juvenile rearing to out-migration was analyzed as year-round, with smolt emigration occurring from January through June. The majority of CCV steelhead spawning in the American River occurs in the upper reaches, between Nimbus Dam and Ancil Hoffman Park, upstream of Watt Avenue. Recently restored habitat at Ancil Hoffman Park, Nimbus Basin, Lower Sailor Bar, and Upper River Bend offer spawning and rearing habitat.

7.3.1.2.2.4.2. Response

The response of CCV steelhead to American River flow management under the proposed action is analyzed below in terms of the stressors impacted: Stranding Risk, Redd Dewatering, Refuge Habitat, Food Availability and Quality and Spawning Habitat.

7.3.1.2.2.4.2.1. Stranding Risk and Redd Dewatering

Flow fluctuations in the Lower American River have been documented to result in CCV steelhead redd dewatering and isolation (Hannon et al. 2003, Water Forum 2005, Hannon and Deason 2008). Redd dewatering can affect salmonid embryos and alevins by impairing development and causing direct mortality due to desiccation, insufficient oxygen levels, waste metabolite toxicity, and thermal stress (Becker et al. 1982, Reiser and White 1983). Isolation of redds in side channels can result in direct mortalities due to these factors, as well as starvation and predation of emergent fry. Hannon et al. (2003) reported that five CCV steelhead redds were dewatered and 10 CCV steelhead redds were isolated in a backwater pool at the lower Sunrise side channel when Nimbus Dam releases were decreased on February 27, 2003. When releases were decreased on March 17, 2003, seven CCV steelhead redds were dewatered and five additional redds were isolated from flowing water at the lower Sunrise side channel. In April 2004 at the lower Sunrise side channel, five CCV steelhead redds were dewatered and “many” redds were isolated (Bratovich et al. 2005). Redd dewatering at Sailor Bar and Nimbus Basin occurred in 2006, with most of the redds being identified as Chinook salmon redds, at least one was positively identified as a CCV steelhead redd, and several more redds were of unknown origin (Hannon and Deason 2008).

Although reports of CCV steelhead redd dewatering and isolation in the Lower American River are only directly observed in certain years, these effects have likely occurred in other years because (1) the pattern of high releases followed by lower releases which occurred during the CCV steelhead spawning period (i.e., primarily January through March) is similar to the pattern observed during the spawning period in many other years (Figure 91); and (2) monitoring was not conducted during many release events and, consequently, impacts were not documented. For example, there were large flow changes of about -30,000 cfs (Water Year 2023) and -80,000 cfs (Water Year 2017), and the resulting drop in river stage can cause or contribute to redd dewatering.

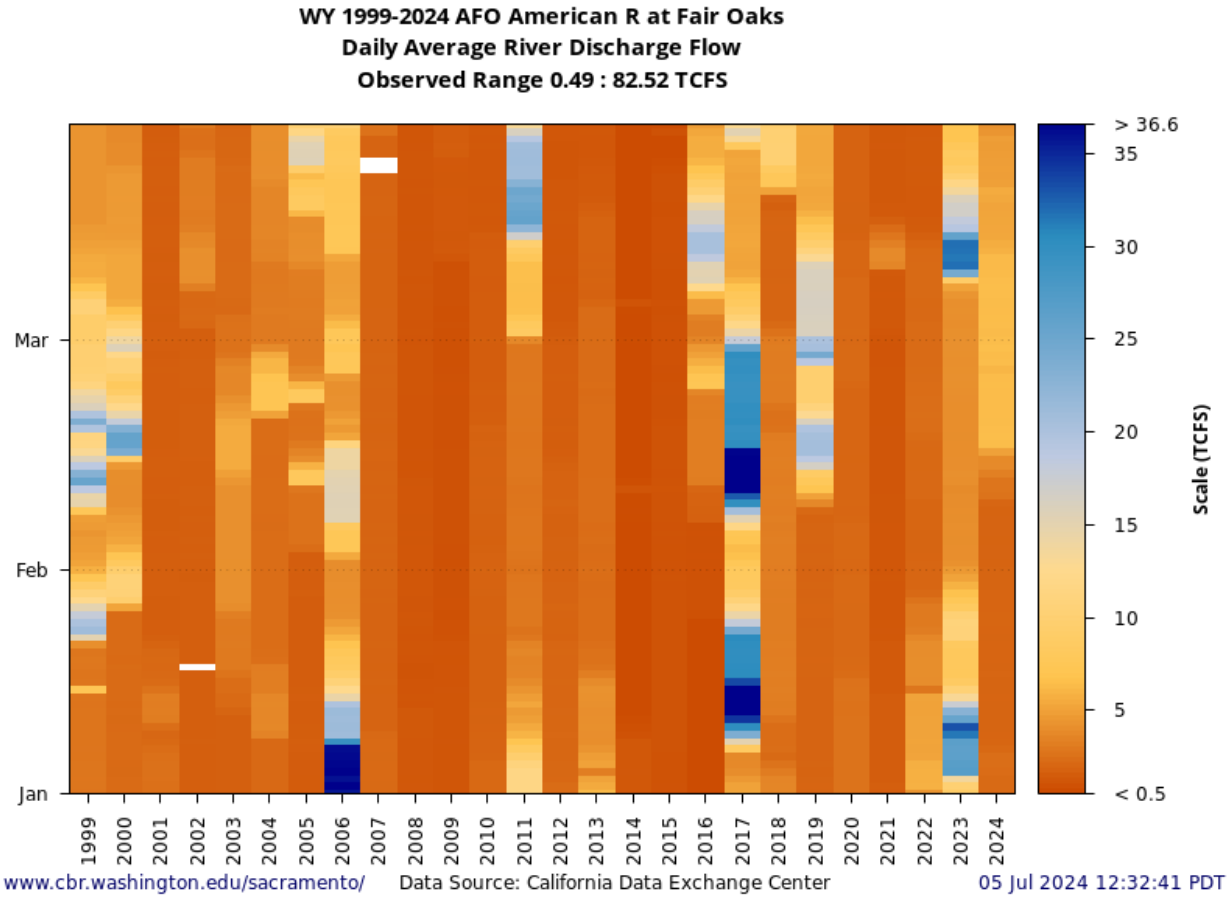


Figure 91. Water Year 1999–2024 American River at Fair Oaks (AFO) Daily Average River Discharge Flow (thousand cubic feet per second [TCFS]).

Source: (University of Washington Columbia Basin Research 2024b). SacPAS All Years River Graph. Available from www.cbr.washington.edu/sacramento/data/query_river_allyears.html.

The mean percent of CCV steelhead redds dewatered for the American River during the January through March spawning period is anticipated to be an average of 27 percent across all water years under the proposed action, ranging from 5 percent in critical years, to 50 percent in wet years. This is nearly identical to the average and ranges anticipated under the NAA and EXP3 (Appendix M, Attachment M, Table X-2 in U.S. Bureau of Reclamation 2023-2024).

Juvenile CCV steelhead stranding and isolation have also been reported to occur in the Lower American River. For example, Bratovich et al. (2005) reported that juvenile CCV steelhead became isolated from the river channel in both 2003 and 2004 following a flow increase and decrease event associated with meeting Delta water quality objectives and demands. Isolated fish are exposed to warm water temperatures and fish and avian predation within habitats that are disconnected from the river, likely increasing their mortality risk. If the isolated habitat is not reconnected to the river with a subsequent increase in river stage, all CCV steelhead in that habitat are assumed to die. As noted in the BA (U.S. Bureau of Reclamation 2023-2024), juvenile stranding surveys were conducted from 2015 to 2022 on the American River. These

surveys found that fish stranding occurred in March and April and peak out-migration for juvenile fish occurs in April and May.

The dewatering risk to redds and stranding of juveniles associated with changes in operations is dependent on the physical attributes of the habitat and the magnitude of the change in flow. Juvenile stranding generally results from reductions in flow that occur over short periods of time, and analytical planning tools cannot predict with certainty the level of effect of possible stranding on fish. Under the proposed action, the risk of flow fluctuations in the river reaches below Nimbus Dam that can strand CCV steelhead is anticipated to continue. The potential for juvenile stranding would also persist as operations continue to target lower reservoir releases in the fall and winter to maximize storage and reserve space for flood control. NMFS expects that stranding of at least a small proportion of the American River population of CCV steelhead juveniles each year will continue with proposed action implementation that will negatively affect exposed individuals, resulting in reduced survival.

In addition to flow fluctuations, sustained low flows also can negatively affect Lower American River CCV steelhead. Yearling CCV steelhead are found in bar complex and side channel areas characterized by habitat complexity in the form of velocity shelters, hydraulic roughness elements, and other forms of cover (Surface Water Resources Inc. 2001). At low flow levels, the availability of these habitat types becomes limited, forcing juvenile CCV steelhead densities to increase in areas that provide less cover from predation. With high densities in areas of relatively reduced habitat quality, juvenile CCV steelhead become more susceptible to predation as well as disease. Flows anticipated under the proposed action are nearly identical to the NAA across all months and water year types. (Appendix F, Figures F.2.2-12-1 through F.2.2-12-18 in U.S. Bureau of Reclamation 2023-2024). Long term average flows during periods of juvenile rearing, such as March and April, will continue to reduce habitat quality and complexity, increase CCV steelhead densities relative to the amount of habitat, and increase their susceptibility to stranding and redd dewatering.

7.3.1.2.2.4.2.2. Reduced Refuge Habitat and Food Availability and Quality

With relation to the stressors Refuge Habitat and Food Availability and Quality, NMFS considers that the managed changes in the hydrograph can reduce access to riparian habitat and instream cover both in the immediate area of releases and further downstream (e.g., less frequent inundation of side channels). Habitat modeling indicated effects that varied by month in the predicted mean instream rearing and floodplain rearing habitat quantities, in acres, for juvenile CCV steelhead in the American River (Table 68). Under the proposed action, instream rearing habitat ranges from 146 to 234 acres, nearly identical to the NAA (146 to 230 acres), and slightly less than under EXP3 (148 to 242 acres). Additionally, floodplain rearing under the proposed action ranges from 13 to 276 acres, similar to the NAA (15 to 272 acres), and EXP3 (3 to 286 acres). Under all three scenarios (proposed action, NAA, and EXP3), instream rearing is highest in October while floodplain rearing is highest in February.

Table 68. Predicted mean instream rearing habitat quantities and floodplain rearing habitat, in acres, for juvenile steelhead in the American River.

Source: Appendix O, Attachment X, Tables 28 and 31 in (U.S. Bureau of Reclamation 2023-2024)

	Mean Juvenile CCV Steelhead Rearing Habitat in American River (acres)					
	Instream			Floodplain		
Month	**Proposed Action**	**NAA**	**EXP3**	**Proposed Action**	**NAA**	**EXP3**
January	184	178	167	219	218	238
February	160	158	154	276	272	286
March	179	177	178	168	165	164
April	177	186	192	155	144	141
May	174	176	191	155	148	138
June	164	166	205	112	106	56
July	146	146	148	148	149	132
August	181	178	218	53	51	3
September	204	203	221	28	27	5
October	234	230	242	13	15	8
November	197	194	169	89	87	200
December	194	190	175	145	145	172

California Central Valley steelhead juvenile rearing has been understood to be a limiting factor in the American River since the construction of Folsom and Nimbus dams (McEwan and Nelson 1991). For example, to mitigate the problem, from 2010 to 2020, 1.2 miles of side channels on the lower American River were created to serve as juvenile rearing zones (CBEC Eco Engineering 2020). Flows under the proposed action will result in nearly the same amount of instream rearing habitat as under NAA operations, indicating that juvenile rearing habitat will continue to be insufficient.

7.3.1.2.2.4.2.3. Spawning Habitat

The expected WUA for CCV steelhead spawning in the American River downstream of Nimbus Dam ranges from about 351,000 (in wet years) to 1,396,000 (in critical years; Appendix M, Attachment M, Table X-2 in U.S. Bureau of Reclamation 2023-2024). Using a different habitat

model indicates that the predicted mean spawning habitat quantities, in acres, for adult steelhead in the American River under the proposed action (117 to 150 acres), is similar to NAA (119 to 154 acres), and EXP3 (117 to 145 acres; Appendix O, Attachment X, Table 6 in U.S. Bureau of Reclamation 2023-2024).

7.3.1.2.2.4.3. Summary of Effects (Proportion of Population and/or Frequency/Likelihood of Occurrence)

Flow fluctuations in the American River under the proposed action are expected to impact a medium proportion of CCV steelhead eggs with a high annual frequency, supporting a medium stressor magnitude classification. The proportion of the population exposed is medium, specifically those redds which are established at relatively higher riverbed elevations and, therefore, shallower water depths. The frequency of exposure is high due to fluctuations every year in releases from Nimbus Dam, but particularly in wet years, most recently 2016, 2017, 2019 and 2023 (Figure 92). Similarly, for adult spawning, the proportion of the population exposed is large with medium frequency (wetter years, or those with substantial flow changes at the beginning of the calendar year when spawning is at its peak). Impacts to juveniles are less certain but expected to impact a medium proportion of the population at a medium frequency that varies within the year.

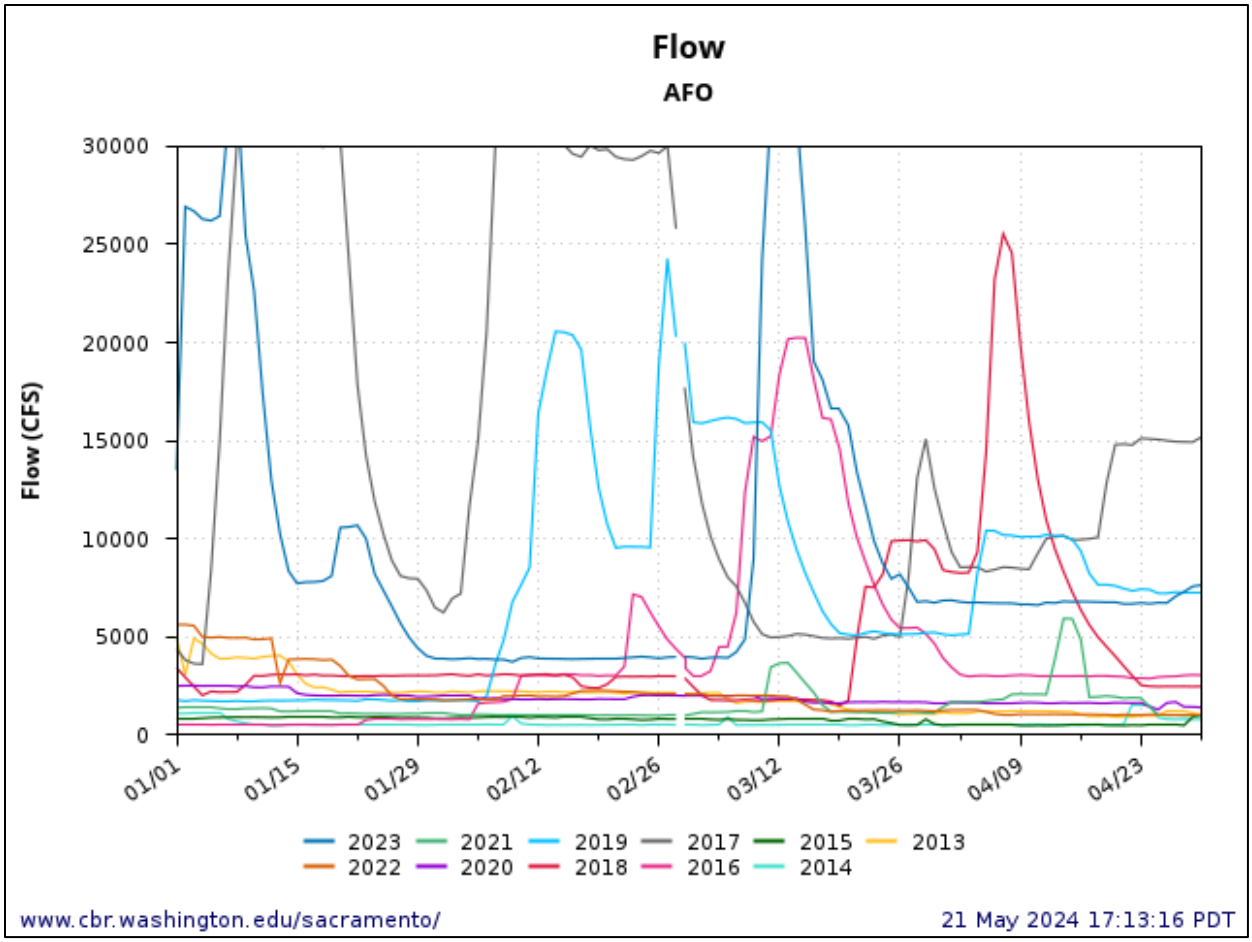


Figure 92. Flow at American River at Fair Oaks (AFO) 2013–2023.

Note the y-axis is truncated to show more detail below 30,000 cubic feet per second (cfs), but 2023 had values slightly above that threshold and 2017 had a max value in excess of 80,000 cfs.

Source: (University of Washington Columbia Basin Research 2024b). SacPAS River Environment Graphics & Text. Available from www.cbr.washington.edu/sacramento/data/query_river_graph.html

7.3.1.2.3. Water Temperature Management

The TMP aims to maintain optimal water temperatures for both CCV steelhead and fall-run Chinook salmon in the Lower American River. Ideally, daily average temperatures between Nimbus Dam and Watt Avenue would not exceed 65°F for CCV steelhead rearing, especially during the active temperature management season from May 15 to October 31. While temperatures below 56°F are ideal for Chinook salmon spawning, which typically occurs from mid-October to January, the Automated Temperature Selection Procedure prioritizes CCV steelhead rearing during summer months. This system sets monthly water temperature targets at Watt Avenue, ranging from 63°F to 72°F depending on the schedule. Schedule 78 has a water temperature upper limit of 72°F from May through November. Schedules 2 through 77 each represent a change in a single month's upper-temperature limit by 1°F. Reclamation has stated that they are open to modifying the Automated Temperature Selection Procedure or utilizing

alternative methods if recommended by the American River Group and fisheries agencies based on specific yearly conditions.

In anticipation of years when the Lower American River experiences temperatures unsuitable for rearing or spawning, Reclamation plans to collaborate with fisheries agencies to assess and mitigate potential impacts. The Automated Temperature Selection Procedure uses the following specific temperature thresholds at different locations along the river or a power bypass during the summer or fall:

- For greater than 65°F at Watt Avenue for May through September (Schedule 28) or higher, the TMP may consider a temperature location at Hazel Avenue.
- For greater than 65°F at Hazel Avenue for May through September, the TMP will include an evaluation of whether modified Folsom operations could support an improved temperature schedule (e.g., an alternate release schedule over the summer).
- For greater than 68°F at Hazel Avenue for May through September, the TMP will include an evaluation of whether modified Folsom operations could support an improved temperature schedule (e.g., an alternate release schedule over the summer) and evaluate a power bypass during the summer and/or fall.
- For greater than 56°F at Hazel Avenue in November, the TMP will evaluate a power bypass in the fall, with the evaluation likely to occur in August and September.

By May 15 of every year, Reclamation will submit a draft TMP and gather technical input from the American River Group, and then finalize the plan by June 15. This TMP will include hydrological and storage forecasts, along with modeling runs to demonstrate achievable temperature compliance schedules. Reclamation will strategize shutter configurations to attain the most optimal temperature schedule, prioritizing CCV steelhead requirements and potentially benefits to fall-run Chinook salmon spawning. During implementation, if temperature thresholds are exceeded for 3 consecutive days or by more than 3°F in a single day, Reclamation will inform NMFS and the American River Group, outlining steps to realign water temperature with the TMP.

7.3.1.2.3.1. California Central Valley Steelhead Exposure and Response

7.3.1.2.3.1.1. Exposure (Life Stage Location and Timing)

Before the construction of Folsom and Nimbus dams, CCV steelhead utilized higher elevation habitats in the basin as thermal refuges (Lindley et al. 2006). Reclamation installed a selective withdrawal system at Folsom Dam in the late 1960s, allowing for limited water temperature management in the Lower American River. This design modification to the steel trash racks provides selective withdrawal capability via three groups of shutters that can pull water from various elevations, which have different temperatures when the lake is thermally stratified.

For this analysis of temperature management, like the analysis of exposure to flow management, adult CCV steelhead migration, holding, and spawning were considered from November through April, with spawning and egg incubation beginning in December, and the former running through April with the latter running through June. This period also coincides with kelt emigration, from December through June, while juvenile rearing to out-migration was analyzed as year-round, with smolt emigration occurring from January through June. The majority of CCV steelhead spawning in the American River occurs in the upper reaches, between Nimbus Dam and Ancil Hoffman Park, upstream of Watt Avenue. Recently restored habitat at Ancil Hoffman

Park, Nimbus Basin, Lower Sailor Bar, and Upper River Bend offer spawning and rearing habitat.

7.3.1.2.3.1.2. Response

7.3.1.2.3.1.2.1. Adult Migration, Holding, and Spawning

Water temperature plays a critical role in the migration and holding patterns of adult CCV steelhead in the American River. Literature reviews indicate that CCV steelhead prefer cooler water temperatures, ideally a 7-day average of the daily maximum temperatures of 62.6-69.8°F, for both migration and holding (Carter 2005). CCV steelhead have been observed spawning in temperatures ranging from 39.0°F to 70.0°F, with a preferred range of 45.0°F to 55.0°F (Carter 2005). Elevated water temperatures can induce physiological stress, potentially delaying or inhibiting their upstream migration and spawning. Additionally, warmer conditions can influence holding behavior, prompting CCV steelhead to seek out thermal refuges, which may negatively impact energy reserves and overall fitness.

Under the proposed action, temperature modeling projects that temperatures will be above the 69.8°F threshold approximately 16 percent of months from July through April, averaged across all years, providing a thermal block to adult CCV steelhead migration in the American River at Watt Avenue (Table 5 in U.S. Bureau of Reclamation 2023-2024). The exceedances in monthly temperatures range from 10 percent (in above normal years) to 30 percent (in critical years) under the proposed action. This is similar (within 2 percent) to expected temperatures under NAA, but less than under EXP3 (about 7 percent less averaged across all water years). Upstream at Hazel Avenue, under the proposed action, only 2 percent of months from July through April (ranging from about 1 in wet years to 4 percent in critical years) were above the 69.8°F lethal water temperature limit for adult steelhead migration (Table 4 in U.S. Bureau of Reclamation 2023-2024).

Lower water temperatures, like those expected at Hazel Avenue, are associated with a reduction in the prevalence of pathogens and diseases, potentially improving the fitness and migration success of adult CCV steelhead. Aquatic pathogens and diseases can spread vertically (parent to offspring) or horizontally (between individuals) as described by (Baxa-Antonio et al. 1992). Seasonal water management practices that reduce river flow can concentrate pathogens, facilitating horizontal transmission and rising water temperatures can increase the virulence of pathogens. Research by McCullough (1999) indicates that diseases affecting salmonids become highly virulent at temperatures exceeding 59.9°F (U.S. Bureau of Reclamation 2023-2024). Migrating and holding adults are more susceptible to pathogens at higher water temperatures. The proposed action is anticipated to result in temperatures greater than 59.9°F during the July through April CCVO steelhead migration period at Hazel Avenue about 38 to 45 percent of the time, depending on water year type, averaging 40 percent over all water years. This is virtually identical to the NAA (less than 1 percent difference for each water year type). Relative to EXP3, the proposed action will decrease the number of months (during July through April) above 59.9°F by about 5 percent (Table 14 in U.S. Bureau of Reclamation 2023-2024). For spawning, under the proposed action the percent of months from December through March outside the 45°F to 55°F water temperature range for successful CCV steelhead spawning is anticipated to be 9 percent at Watt Avenue and 4 percent at Hazel Avenue (Tables 21 and 22 in U.S. Bureau of Reclamation 2023-2024). Water temperatures will be particularly stressful and not supportive of

CCV steelhead spawning during critical years, when the proposed action will result in 25 percent of months from December through March outside of the 45°F to 55°F water temperature range.

7.3.1.2.3.1.2.2. Embryo Incubation

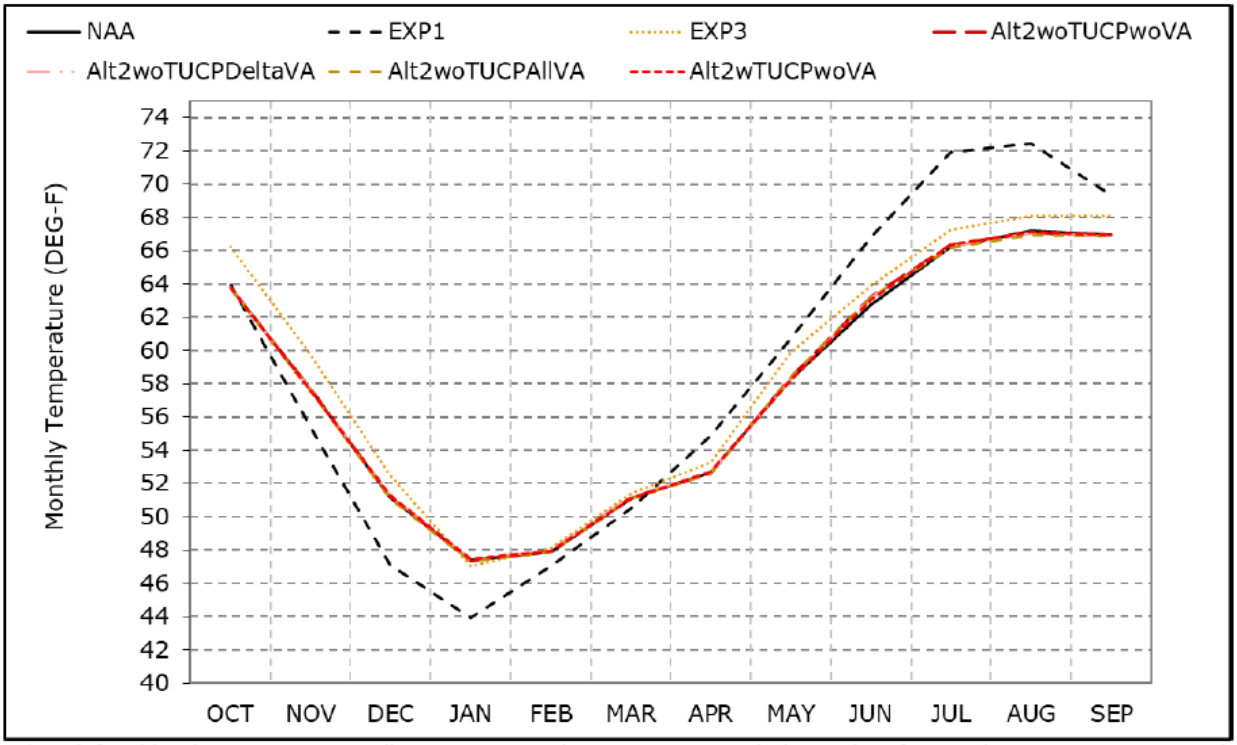
Myrick and Cech Jr (2001) examined the effects of water temperature on CCV steelhead (and Chinook salmon) with a specific focus on Central Valley populations and reported that CCV steelhead egg survival declines as water temperature increases past 50°F. In a summary of technical literature examining the physiological effects of temperature on anadromous salmonids in the Pacific Northwest, the EPA (2001) reported that CCV steelhead egg and alevin survival would decline with exposure to constant water temperatures above 53.6°F. Rombough (1988), as cited in EPA (2001), found less than 4 percent embryonic mortality of CCV steelhead incubated at 42.8, 48.2, and 53.6°F, but noted an increase to 15 percent mortality at 59°F. In this same study, alevin mortality was less than 5 percent at all temperatures tested, but alevins hatched from eggs that were incubated at 59°F were considerably smaller and appeared less well developed than those incubated at the lower test temperatures.

In a laboratory study examining the survival and development of CCV steelhead eggs incubated at either 46.4°F or 64.4°F, Turner et al. (2007) found that eggs incubated at the higher temperature experienced higher mortality, with 100 percent mortality of eggs from one of three treatments at the higher temperature. Also, those fish incubated at the higher temperature that did survive exhibited greater structural asymmetry than fish incubated at the lower temperature. Similar to Turner et al. (2007), Myrick and Cech Jr (2001) reported an increase in physical deformities in CCV steelhead that were incubated at higher water temperatures. Structural asymmetry has been negatively correlated with fitness in rainbow trout (Leary et al. 1984). Overall, the literature indicates that CCV steelhead egg mortality increases at and above a range of 54°F to 57°F (Myrick and Cech Jr 2001, EPA 2001, Bratovich et al. 2012).

Given that the literature results are from laboratory studies, CCV steelhead eggs incubating in the redds in the river may need even colder temperatures than 54°F to have high survival. Martin et al. (2017) found strong evidence that significant thermal mortality occurred during the embryonic stage in Chinook salmon in some years due to a reduction in thermal tolerance in the field compared to laboratory studies. Martin et al. (2017) used a biophysical model of oxygen supply and demand to demonstrate that such discrepancies in thermal tolerance could arise to differences in oxygen supply in lab and field contexts. Because oxygen diffuses slowly in water, as embryos consume oxygen, they deplete the concentration of oxygen in the surrounding water, reducing their rate of oxygen supply. This is exacerbated in warm waters because oxygen demand increases exponentially with temperature. Flowing water replenishes oxygen through convective transfer, and thereby increases oxygen supply. Thus, higher flows deliver more oxygen to embryos than low flows, allowing for higher thermal tolerance. The Chinook salmon egg survival temperature relationships found in laboratory studies likely overestimate the thermal tolerance of eggs developing in the river by roughly 5.4°F because those studies typically take place at relatively high flows compared to flows experienced by eggs in spawning gravels in the river (Martin et al. 2017). Furthermore, the ongoing warming of the climate poses a significant challenge for embryonic development within eggs, as their oxygen demand increases exponentially with temperature while supply, limited by diffusion across the egg surface, remains relatively constant (Martin et al. 2020). This issue likely applies to what is known about the relationship between thermal tolerance and CCV steelhead survival given that, like Chinook

salmon, CCV steelhead eggs incubate under the water column in spawning gravels. The limits of thermal tolerance are set by oxygen supply and demand. As CCV steelhead eggs are smaller than Chinook salmon eggs, their oxygen needs may be lower. However, a study using brown trout (*Salmo trutta*) and Atlantic salmon (*S. salar*) eggs found that oxygen consumption increases relatively slowly with increasing egg mass (Einum et al. 2002). Therefore, the effects of increased water temperature associated with decreased oxygen supply are expected to be similar for CCV steelhead eggs and Chinook salmon eggs.

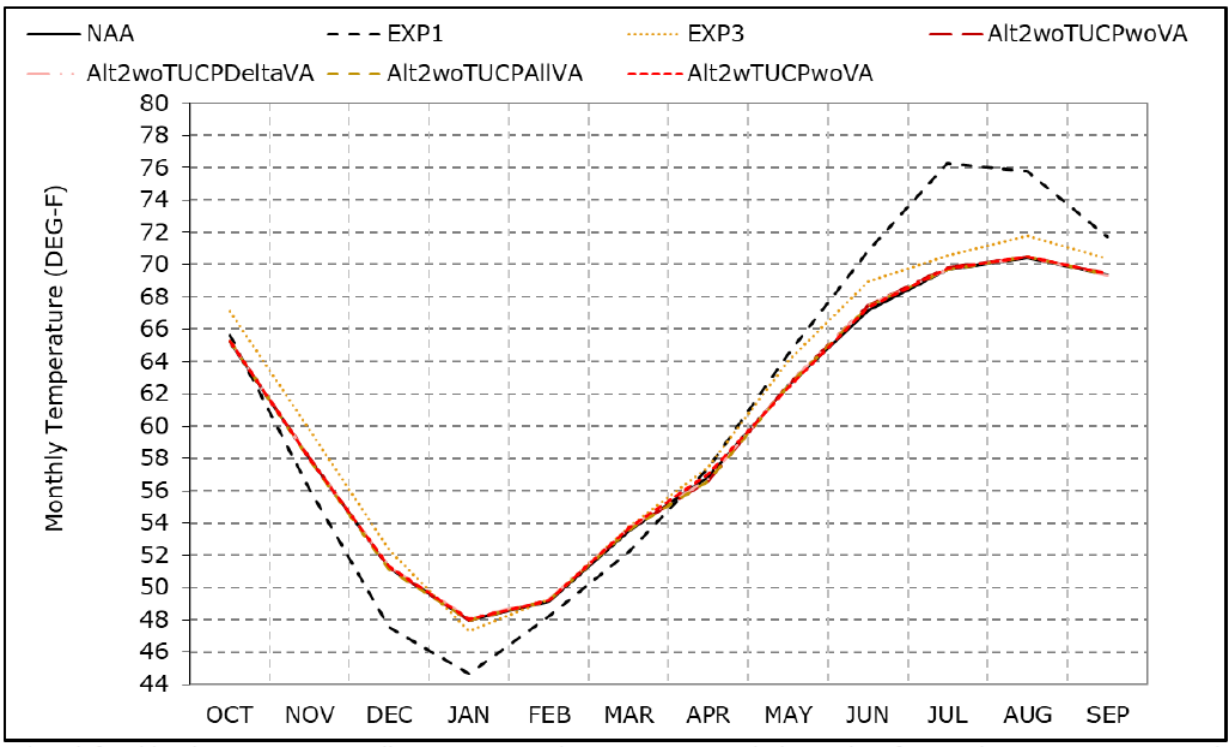
Modeled water temperatures demonstrate that CCV steelhead eggs will be exposed to stressful conditions with implementation of the proposed action. Water temperatures are expected to be over 54°F starting in March at Watt Avenue and in April below Nimbus Dam under the proposed action (Alt2woTUCPwoVA [also referred to as Alt2v1] in Figure 93 and Figure 94). The operations of Folsom and Nimbus dams dampen the monthly variability in temperature. At Watt Avenue, median April temperatures are 56.2°F under the proposed action (Alt2v1), versus 56.0°F under NAA (a 0.2°F decrease) and 57.7°F under EXP3 (a 1.5°F increase, Figure 95). In May, median temperatures are expected to be 62.6°F under the proposed action (Alt2v1), versus 63.0°F under the NAA (a 0.4°F increase) and 64.6°F under EXP3, a 2.0°F increase (Figure 96).



*As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).
*These results are displayed with calendar year - year type sorting.
*All scenarios are simulated at 2022 Median climate condition and 15 cm sea level rise.

Figure 93. American River below Nimbus Dam, long-term average temperature.

Source: Appendix F, Figure F.2.11-13-1 in (U.S. Bureau of Reclamation 2023-2024)



*As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).
*These results are displayed with calendar year - year type sorting.
*All scenarios are simulated at 2022 Median climate condition and 15 cm sea level rise.

Figure 94. American River at Watt Avenue, long-term average temperature.

Source: Appendix F, Figure F.2.11-14-1 in (U.S. Bureau of Reclamation 2023-2024)

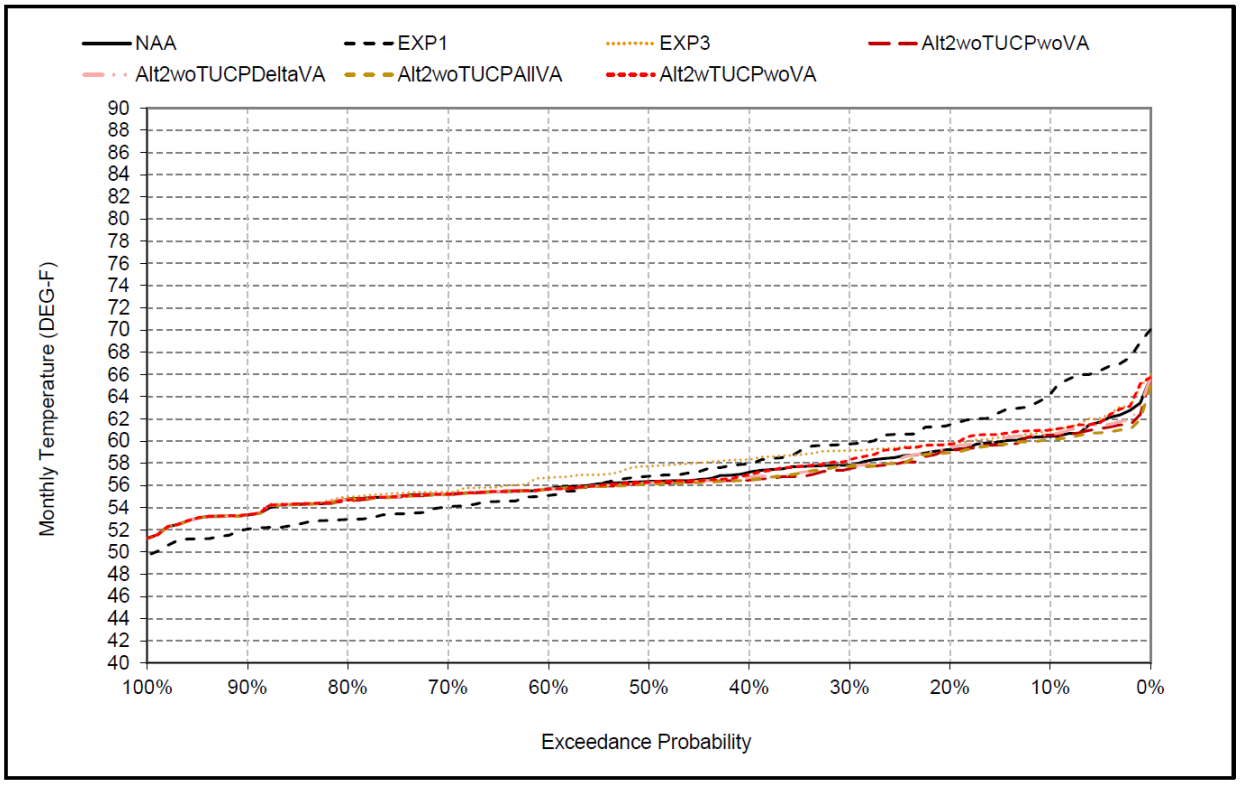


Figure 95. American River at Watt Avenue, April.

Source: Figure F.2.11-14-13 in (U.S. Bureau of Reclamation 2023-2024)

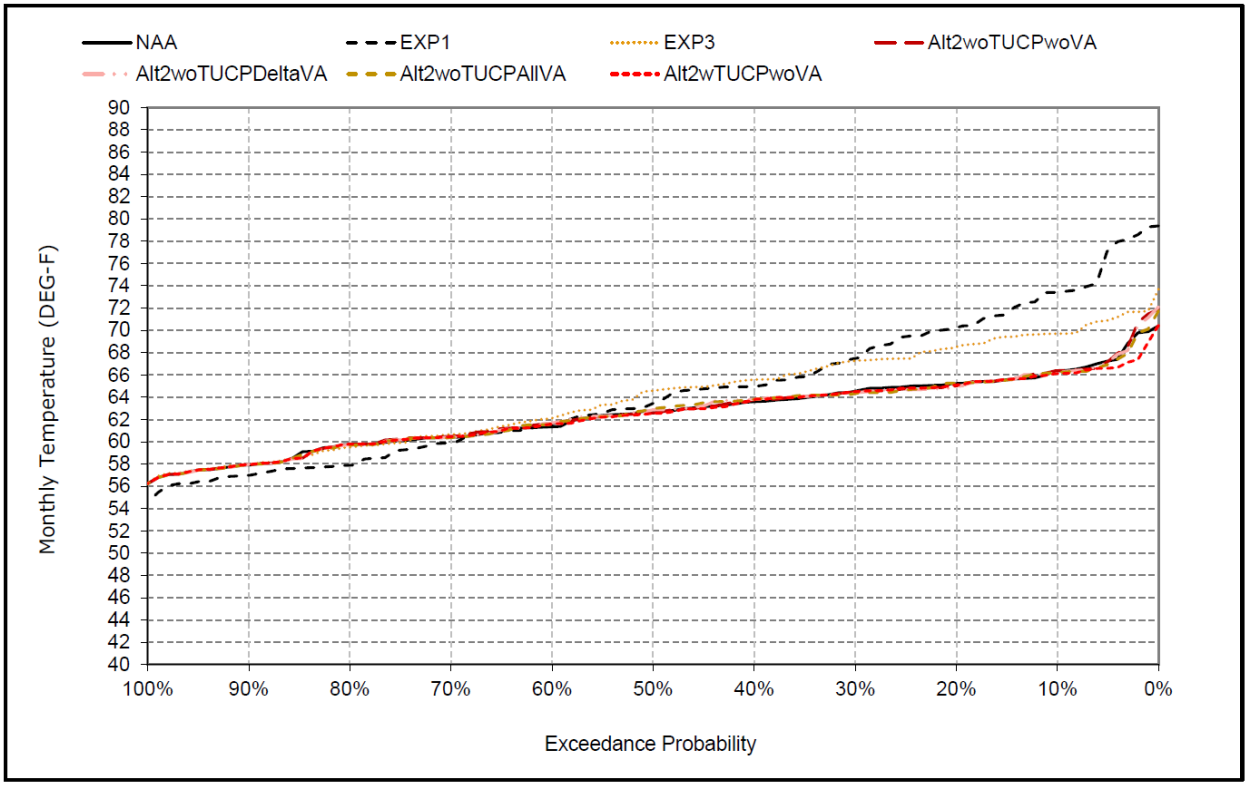


Figure 96. American River at Watt Avenue, May.

Source: Figure F.2.11-14-14 in (U.S. Bureau of Reclamation 2023-2024)

The percent of months from December through May outside the 45°F to 52°F optimal egg incubation water temperature range for CCV steelhead averaged across all years is expected at Watt Avenue to be 55 percent under the proposed action, 54 percent under the NAA and 58 percent under EXP3. Upstream at Hazel Avenue, the percent of months exceeding the optimal egg temperature range is 43 percent under the proposed action, 42 percent under the NAA and 50 percent under EXP3 (Tables 45 and 46 in U.S. Bureau of Reclamation 2023-2024). These impacts under the proposed action range from 45 percent in wet years, increase in drier years, up to 67 percent in critical years. Even in the best case scenario, during wet years, 34 percent (at Hazel Avenue) and 45 percent (at Watt Avenue) of months will be outside the optimal egg incubation water temperature range. Due to the increasing temperatures as the season progresses, higher egg mortality and increased fitness consequences would occur for CCV steelhead eggs and alevins that were spawned later in the spawning season (e.g., spawned in March or April rather than January). This selective pressure towards earlier spawning and incubation under the proposed action would continue to constrain the temporal distribution of spawning, resulting in a decrease in population diversity, and consequently a likely decrease in abundance. The net impact is very stressful to CCV steelhead egg incubation because under the proposed action, 55 percent of the months (and 67 percent in critical years) will be outside the previously mentioned optimal temperature range. Additionally, the impact of pathogen virulence water temperature on CCV steelhead egg incubation and fry emergence was analyzed for December through May. Under the proposed action, 4 percent of months at Hazel Avenue and 15 percent of months at

Watt Avenue would be above this temperature threshold. This is nearly identical to the NAA (within 1 percent) but results in a 3-percent decrease at Hazel Avenue and a 1-percent decrease at Watt Avenue of the proposed action relative to EXP3 in the number of months above the 59.9°F pathogen virulence water temperature threshold (Table 50 and 51 in U.S. Bureau of Reclamation 2023-2024). However, in critical years, this will result in exceedances of this threshold in 7 percent of months at Hazel Avenue and 24 percent at Watt Avenue.

Additionally, dissolved oxygen plays an important role in the survival and healthy development of juvenile CCV steelhead eggs in the American River. Low dissolved oxygen levels can cause significant stress and even mortality, particularly in the vulnerable early life stages. Insufficient oxygen can lead to slower growth rates, smaller size at hatching, and a higher incidence of deformities. It can also impair yolk absorption, leaving alevins weaker and less likely to survive. Low dissolved oxygen can hinder their emergence from the gravel, making them more susceptible to predators. Several factors in the American River influence dissolved oxygen levels, including water temperature, flow rate, organic matter, and pollution. Warmer temperatures and lower flows, often seen during summer months and droughts, can reduce dissolved oxygen. Recent observations found low levels of dissolved oxygen coming out of Folsom into Lake Natoma, but there is some variation driven by which dam gate is open at the time which impacts aeration. The Central Valley Regional Water Quality Control Plan requires dissolved oxygen of at least 7.0 mg/L from Folsom Lake to the Sacramento River, while observations in Lake Natoma in 2023 were in the 5-6 mg/L range, depending on water depth.

7.3.1.2.3.1.2.3. Juvenile Rearing and Out-Migration

Water temperatures in the Lower American River often reach and exceed levels that are stressful to juvenile rearing CCV steelhead, particularly during the summer and early fall. Assessing the response of American River CCV steelhead juveniles to water temperatures is challenging due partly to a historical paucity of published primary literature (Myrick and Cech 2004). Though there has been a more recent increase in studies and modeling of growth and anadromy patterns using temperature as a variable (Sogard et al. 2012, Beakes et al. 2014, Kendall et al. 2014, Satterthwaite et al. 2014), there remains a fairly substantial knowledge gap in relation to the effects of temperature on juvenile CCV steelhead.

The available information suggests that American River juvenile CCV steelhead may be more tolerant to high temperatures than CCV steelhead from regions further north (Myrick and Cech 2004). Cech Jr and Myrick (1999) reported that when American River CCV steelhead were fed to satiation at constant temperatures of 51.8°F, 59.0°F, and 66.2°F, growth rates increased with temperature, whereas Wurtsbaugh and Davis (1977) found that maximal growth of juvenile CCV steelhead from North Santiam River in Oregon occurred at a cooler temperature (i.e., 62.6°F). Furthermore, Beakes et al. (2014) found that CCV steelhead sourced from Coleman National Fish Hatchery and reared at 68°F maintained an average growth rate above 0.6 millimeters per day, but only when a daily food ration equal to 6 percent of the total wet fish biomass was fed. All of these studies were conducted in a controlled laboratory setting with unlimited, or relatively high, food availability. Under more variable conditions, such as those experienced in the wild, the effect of water temperature on juvenile CCV steelhead growth would likely be different. For example, Beakes et al. (2014) found that treatments of high water temperature and low rations resulted in the lowest growth rate. Additionally, a field study conducted from 2006 through 2009 estimated that average summer and fall growth of juvenile CCV steelhead in the

American River ranged from 0.98 to 1.12 millimeters per day despite maximum summer temperatures regularly exceeding 68°F (Sogard et al. 2012). This rate of growth is unusually high for CV salmonids and exceeds growth rates obtained by fish rearing on managed floodplains in the California Central Valley (e.g., Katz et al. 2017). A 2014 CDFW study on the American River found high growth rates (1.23 to 1.38 millimeters per day) among a small sample of marked and recaptured fish (California Department of Fish and Wildlife 2014b). Sogard et al. (2012) postulate that this rate of accelerated growth is likely the result of low CCV steelhead density and high food availability, which further illustrates the interactive role of water temperature and food availability in modulating growth in salmonids (Manhard et al. 2018).

Even with this tolerance for warmer water temperatures, juvenile CCV steelhead in the Lower American River exhibit symptoms of thermal stress. Elevated water temperatures can increase physiological stress and subsequently, decrease immune system function. For example, the occurrence of a bacterial-caused inflammation of the anal vent (commonly referred to as "rosy anus") of American River CCV steelhead has been reported by CDFW to be associated with warm water temperatures. Sampling in the summer of 2004 showed that this vent inflammation was prevalent in CCV steelhead throughout the river and the frequency of its occurrence increased as the duration of exposure to water temperatures over 65°F increased. At one site, the frequency of occurrence of the anal vent inflammation increased from about 10 percent in August, to about 42 percent in September, and finally up to about 66 percent in October (Bratovich et al. 2005).

The juvenile CCV steelhead immune system functions properly up to about 60°F and then is dramatically compromised as water temperatures increase into the upper 60s (°F, Bratovich et al. 2005). CDFW reported that, in 2004, the anal vent inflammation occurred when juvenile CCV steelhead were exposed to water temperatures above 65°F (Bratovich et al. 2005). From 1999 through 2023, daily mean water temperatures during the summer at Watt Avenue were frequently above 65°F, with a maximum of about 75°F in July of 2021 (Figure 97). CDFW has suggested that these observations are associated with the debilitation of the CCV steelhead's immune system responses (Bratovich et al. 2005); they, therefore, may be indicative of an increased susceptibility to and decreased ability to deal with disease, which would decrease fitness.

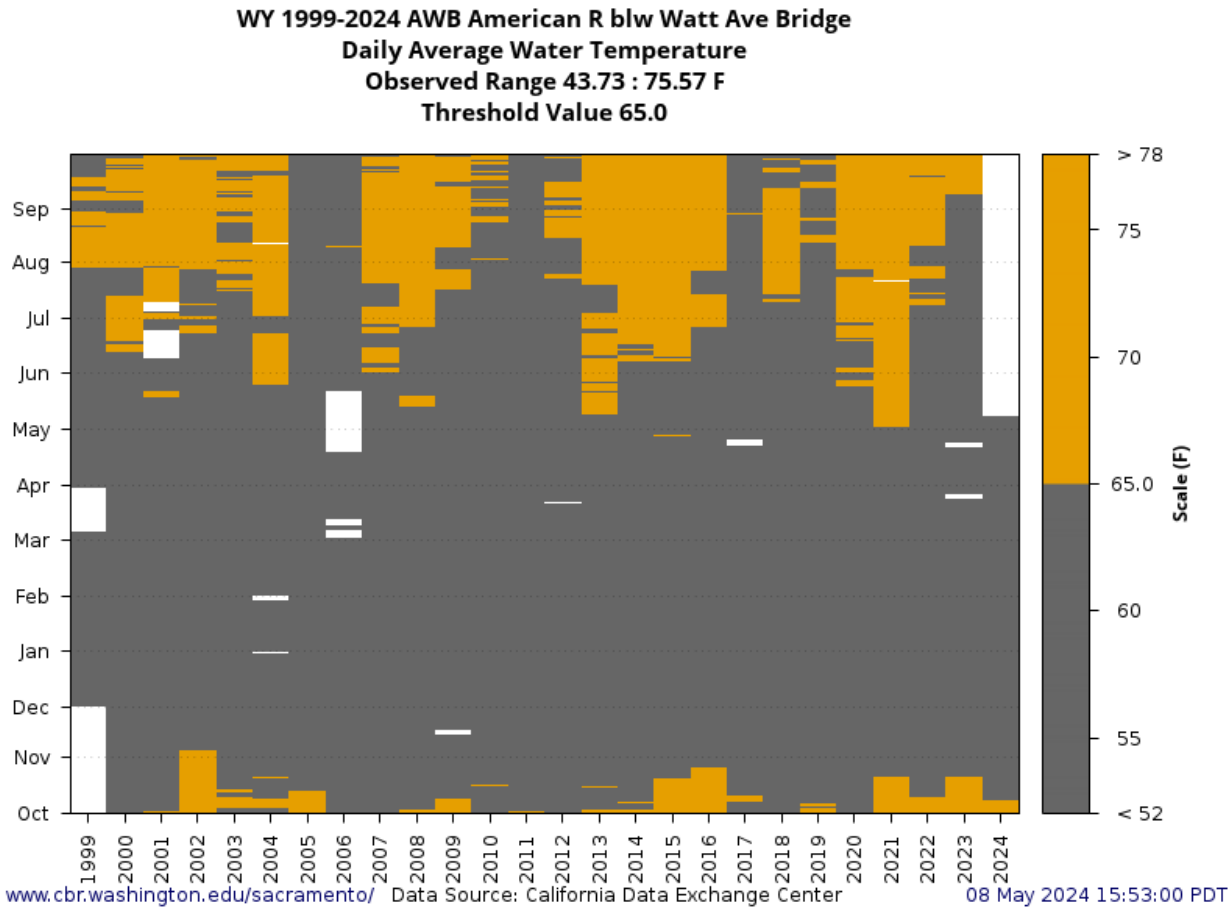


Figure 97. Lower American River water temperature from 1999 through mid-2024 represented as the daily mean at the Watt Avenue gauge.

The >65°F threshold is indicated in orange because visible symptoms of thermal stress in juvenile California Central Valley steelhead are associated with exposure to daily mean water temperatures above 65°F.

Source: (University of Washington Columbia Basin Research 2024b). SacPAS All Years River Graph. Available from www.cbr.washington.edu/sacramento/data/query_river_allyears.html

Under the proposed action, the percentage of months that temperatures are expected to be above the 59.9°F pathogen virulence water temperature threshold for juvenile CCV steelhead rearing and out-migration at Hazel Avenue is 43 percent and at Watt Avenue is 50 percent; this is a large potential impact of pathogens on juvenile CCV steelhead (Tables 62 and 63 in U.S. Bureau of Reclamation 2023-2024). The percentage of months above the threshold in drier years is higher, for example during critical years 50 percent of months at Hazel Avenue and 58 percent at Watt Avenue are expected under the proposed action to be above the 59.9°F pathogen virulence water temperature threshold for juvenile CCV steelhead rearing and out-migration. Lower American River water temperatures have not improved over at least the last 25 years (Figure 98).

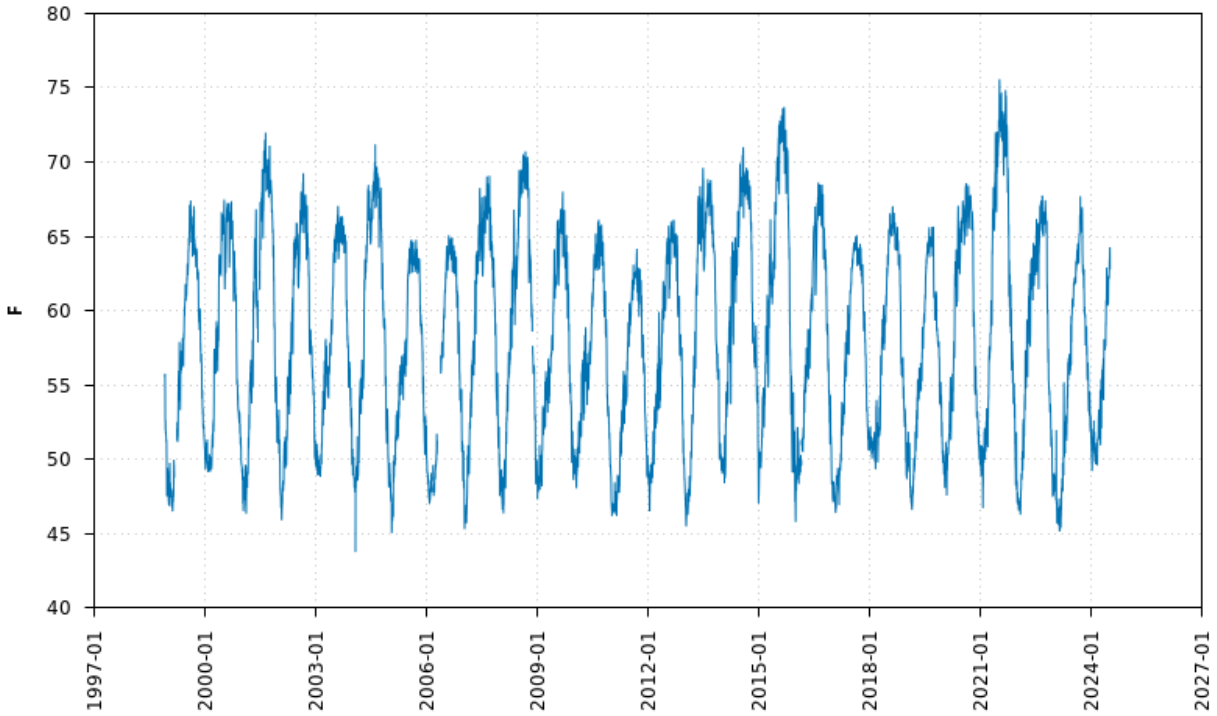


Figure 98. American River Below Watt Avenue Bridge Daily Average Water Temperatures (°F) 1998–2024.

Source: (U.S. Bureau of Reclamation 2023-2024). SacPAS All Years River Graph. Available from www.cbr.washington.edu/sacramento/data/query_river_allyears.html.

Temperatures anticipated under the proposed action are not assumed to solve the thermal challenges in the Lower American River. Specifically, at Watt Avenue, as previously mentioned, across all water years, 50 percent of months are expected to exceed the pathogen virulence water temperature threshold for juvenile CCV steelhead, virtually the same as NAA. The BA does not include information supporting the notion that the Lower American River habitat will be thermally suitable for the juvenile life stage during warmer months or drier water years.

As described in Water Forum (2005), Folsom Dam is commonly operated to meet water quality objectives and demands in the Delta. These operations limit cold water pool availability in Folsom Reservoir, thereby potentially resulting in elevated water temperatures in the Lower American River, which likely results in increased predation rates on rearing juvenile CCV steelhead. Juvenile rearing CCV steelhead may be exposed to increased predation due to both increased predator abundance and increased activity, digestion and consumption rates of these predators associated with higher water temperature (Vigg and Burley 1991, Vigg et al. 1991, McInturf et al. 2022).

7.3.1.2.3.1.2.4. Smolt Emigration

To successfully complete the parr-smolt transformation, a physiological and morphological adaptation to life in saline water, smolting CCV steelhead require cooler water temperatures than for the rearing life stage. Adams et al. (1975) reported that CCV steelhead undergo the smolt transformation when reared in water temperatures below 52.3°F, but not at warmer water

temperatures. In a report focusing on the thermal requirements of Central Valley salmonids, Myrick and Cech Jr (2001) came to a similar conclusion, stating that CCV steelhead successfully smolt at water temperatures in the 43.7°F to 52.3°F range. Others have suggested that water temperatures up to about 54°F will allow for successful CCV steelhead smoltification (Zaugg et al. 1972, Wedemeyer et al. 1980, EPA 2001).

The BA analyzes a 55°F upper limit of successful smoltification (Appendix M, Attachment M in Reclamation 2023-2024), citing Zaugg et al. (1972), Wedemeyer et al. (1980), and EPA (2003). Under the proposed action, the 55°F temperature threshold for the CCV steelhead out-migration cue from January through May will be exceeded approximately 20 percent of the time at Hazel Avenue (from 19 percent during wet years to 25 percent during critical years), and 41 percent of the time at Watt Avenue (from 26 percent during wet years to 60 percent during critical years). The anticipated monthly temperatures are nearly identical (within about 1 percent) between the proposed action and the NAA. Relative to EXP3, the proposed action will decrease the percent of time by 2 percent at Watt Avenue and 1 percent at Hazel Avenue (Table 68 and 69 in Reclamation 2023-2024). CCV steelhead smolt emigration in the Lower American River occurs from January through June (Surface Water Resources Inc. 2001). Monitoring data from 1999 to 2024 showed that Lower American River water temperatures frequently exceeded 52°F by March and 54°F by April (Figure 99).

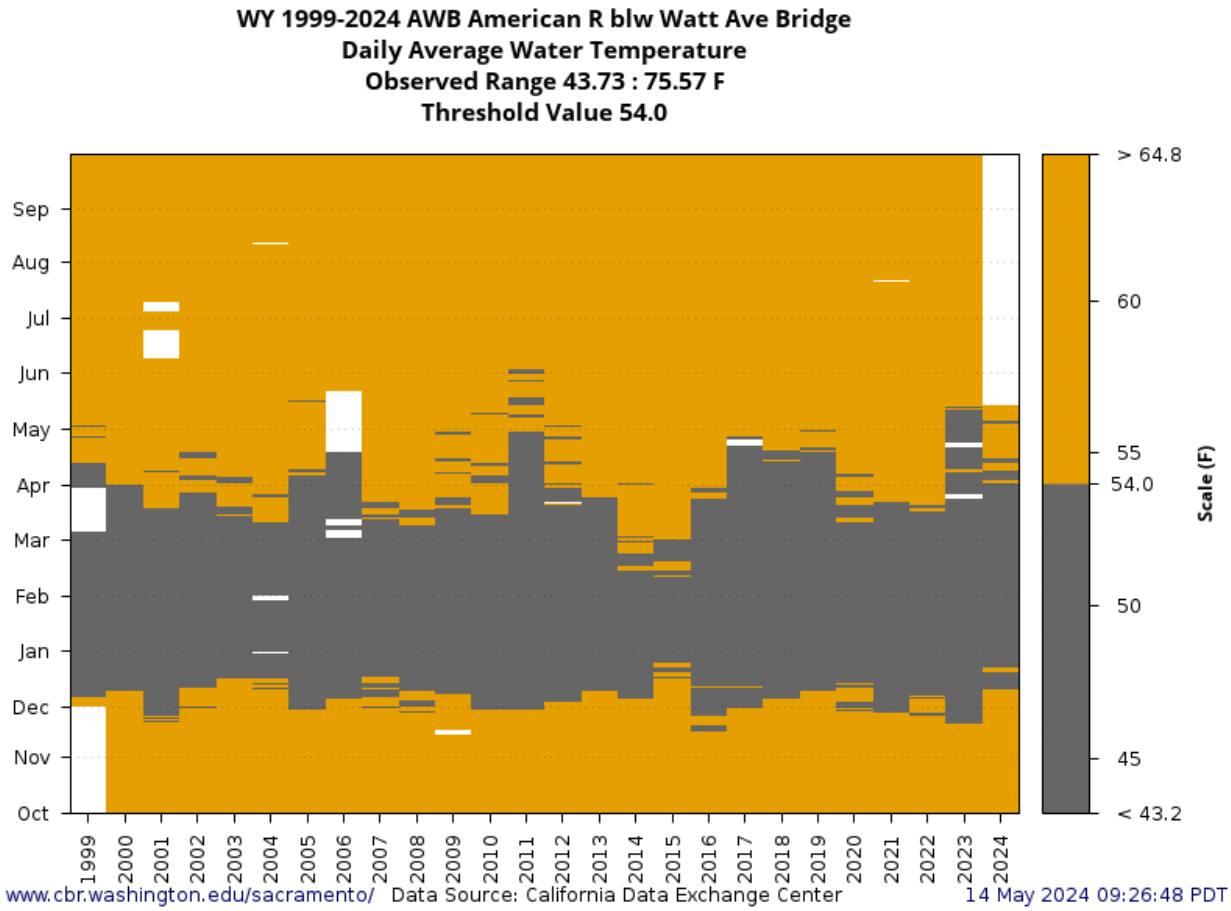


Figure 99. American River below Watt Avenue Bridge temperatures.

Source: (University of Washington Columbia Basin Research 2024b). SacPAS All Years River Graph. Available from www.cbr.washington.edu/sacramento/data/query_river_allyears.html.

Based on the thermal requirements for CCV steelhead smolts described above, it could be hypothesized that smolt transformation is likely inhibited by exposure to Lower American River water temperatures. However, research has shown that most CCV steelhead in the Lower American River express an anadromous life history (Satterthwaite et al. 2010, Sogard et al. 2012). Their results support the conclusion that the majority of juvenile CCV steelhead undergo smolt transformation and emigrate as they reach age 1 (Satterthwaite et al. 2010, Sogard et al. 2012). However, Sogard et al. (2012) caution that this early emigration may be associated with high water temperatures in the Lower American River and that "there may be negative aspects that were not addressed in [their] study, such as disease or reduced thermal tolerance of older juveniles." It remains uncertain how increased warming associated with climate change will impact the successful transformation of parr to smolts in the Lower American River.

Reclamation's modeled water temperatures demonstrate that the proposed action is expected to result in conditions that will inhibit the successful transformation from parr to smolts. For example, exceedance plots show that water temperatures at Watt Avenue will average 54°F in March, based on the 100-year simulation period, and exceed that temperature 80–90 percent of the time by April. In May to June water temperatures are well above the threshold, expected to

average 63–67°F under the proposed action (Tables F.2.11-14-5b and F.2.11-14-6b in U.S. Bureau of Reclamation 2023-2024). These data suggest that parr are expected to experience sublethal thermal impacts hindering smoltification under the proposed action for at least the proportion of CCV steelhead emigrating in April, May, and June.

7.3.1.2.3.1.2.5. Kelt Emigration

Water temperature plays a pivotal role in the health and survival of CCV steelhead kelts emigrating from the American River during the February to June period. Elevated temperatures within this timeframe can create a combination of physiological stressors that compromise the immune system of these post-spawning fish. As kelts experience natural immunosuppression after spawning, warmer waters amplify this vulnerability by fostering the growth and proliferation of opportunistic pathogens. This increase in pathogen abundance, coupled with the weakened immune response of kelts, creates a conducive environment for infections to take hold.

The consequences of heightened pathogen virulence can be severe. Infected kelts may experience increased mortality rates during their downstream migration and subsequent ocean entry. Additionally, those that survive may suffer from reduced reproductive success in future spawning events due to lingering physiological impairments. This cascade of negative effects can ultimately impact the overall population dynamics and resilience of CCV steelhead in the American River.

Temperature modeling indicates that the percentage of months from February through June above the 59.9°F pathogen virulence water temperature threshold for kelt emigration, for all years combined, is 21 percent. The temperature exceedances range from 11 percent in wet years to 29 percent in critical years. This is expected to present a thermal barrier to many kelts migrating through this part of the American River from February through June (Tables 38 and 39 in U.S. Bureau of Reclamation 2023-2024).

7.3.1.2.4. American River Division Effects Analysis Summary

This section summarizes the Flow Management and Water Temperature Stressors, and includes summary tables of temperature impacts. It then summarizes the Exposure and Response for the stressors analyzed.

7.3.1.2.4.1. Summary of Flow Management Stressors

Because the modeling indicates that 27 percent of CCV steelhead redds are likely to be dewatered under the proposed action, this component of the proposed action has the potential for a magnitude medium lethal impact on egg incubation to fry emergence. Additionally, although not quantified by modeling, a high lethal impact of stranded juveniles is expected, based on rescues that have occurred historically.

Inadequate access to instream rearing in the spring and summer under the proposed action will have a medium magnitude sublethal effect on both refuge habitat and food availability and quality for juvenile rearing to out-migration.

Spawning habitat, measured via WUA, is expected to decrease slightly for the proposed action (about 928,000) relative to the NAA (about 949,000), which is expected to provide inadequate spawning areas for CCV steelhead based on the historic limitation in this habitat.

In combination, redd dewatering (27 percent of redds averaged across all years), inadequate access to spawning habitat (which will decrease relative to the NAA), and stranding and inadequate rearing habitat for juveniles (both expected to continue based on similarity of proposed action flows to the NAA), are predicted to result in relatively stressful conditions of flow variations that have historically stranded juveniles and dewatered redds, truncated spawning habitat, and limited access to floodplain and instream rearing.

7.3.1.2.4.2. Summary of Water Temperature Management Stressors

The effects analysis results suggest that water temperature will be a high magnitude stressor on CCV steelhead. The temperature effects of the proposed action are summarized in Table 69, Table 70, and Table 71. The resulting temperatures from the proposed action do not meet the temperature target at Watt Avenue and Hazel Avenue for nearly all life stages analyzed. The proposed action will result in temperatures in excess of the targets for adult migration and spawning, kelt emigration, egg incubation and fry emergence, juvenile rearing, and out-migration. The highest frequency of exceedances are both at Watt Avenue, specifically exceedance in 55 percent of months for egg incubation and 50 percent for juvenile rearing and out-migration pathogens. The impacts also extend upstream, with 43 percent of months exceeding both the egg incubation and the juvenile rearing and out-migration pathogens thresholds.

Table 69. Water temperature effects of the proposed action on the American River for the California Central Valley steelhead adult life stage. Percentages are rounded to the nearest whole number for easier interpretation.

Life Stage	Adult Migration		Adult Migration Pathogen Virulence	Adult Spawning	
Time Frame	July - April			December - March	
Temperature Target	69.8°F			45°F to 55°F	
Location	Hazel Avenue	Watt Avenue	Hazel Avenue	Hazel Avenue	Watt Avenue
Source*	Table 4	Table 5	Table 14	Table 21	Table 22
% Months Outside (PA)	2%	16%	40%	4%	9%

*Source: Compiled from Reclamation (U.S. Bureau of Reclamation 2023-2024)

Table 70. Water temperature effects of the proposed action on the American River for the California Central Valley steelhead kelt life stage. Percentages are rounded to the nearest whole number for easier interpretation.

Life Stage	Kelt Emigration Impairment	Kelt Emigration Lethal Limit	Kelt Emigration Pathogens
Time Frame	February - June		
Temperature Target	66.2°F	69.8°F	59.9°F

Life Stage	Kelt Emigration Impairment		Kelt Emigration Lethal Limit		Kelt Emigration Pathogens	
Location	Hazel Avenue	Watt Avenue	Hazel Avenue	Watt Avenue	Hazel Avenue	Watt Avenue
Source*	Table 27	Table 28	Table 29	Table 30	Table 38	Table 39
% Months Outside (PA)	3%	15%	0%	6%	21%	38%

*Source: Compiled from Reclamation (U.S. Bureau of Reclamation 2023-2024)

Table 71. Water temperature effects of the proposed action (PA) on the American River for California Central Valley steelhead egg, fry, and juvenile life stages. Percentages are rounded to the nearest whole number for easier interpretation.

Life Stage	Egg Incubation		Egg Incubation and Fry Emergence Pathogen Virulence		Juvenile Out-migration		Juvenile Rearing and Out-migration Pathogen Virulence	
Time Frame	December - May				January - May		Year-round	
Temperature Target	45°F to 52°F		59.9°F		55°F		59.9°F	
Location	Watt Avenue	Hazel Avenue	Hazel Avenue	Watt Avenue	Hazel Avenue	Watt Avenue	Hazel Avenue	Watt Avenue
Source*	Table 45	Table 46	Table 50	Table 51	Table 68	Table 69	Table 62	Table 63
% Months Outside (PA)	55%	43%	4%	15%	20%	41%	43%	50%

*Source: Compiled from (U.S. Bureau of Reclamation 2023-2024)

7.3.1.2.4.3. Summary of Stressors

The impacts of temperature, along with other stressors, are summarized in Table 72 and Table 73. In cases where there is more than one stressor effect, the most frequent or highest magnitude effect is displayed in the table, but the less frequent effect is noted under the expected change of fitness and discussed above in the body of the document.

The proposed action is expected to have mixed effects on the American River CCV steelhead population. Water temperature will remain a significant stressor under the proposed action, with exceedances that impair fitness predicted for several life stages, notably 43 to 55 percent of months for egg incubation, 43 to 50 percent of months for juvenile rearing and out-migration pathogen virulence and 20 to 41 percent of months for juvenile out-migration.

The proposed action will likely have a small effect on CCV steelhead redd dewatering. There is an anticipated high mortality risk for stranded juveniles, although this was not directly quantified in the modeling. Changes in floodplain and instream rearing habitat availability will likely have a moderate sub-lethal effect on juvenile CCV steelhead. Adult spawning habitat is expected to see slight improvements under the proposed action, but with a minor decrease during critical years.

Overall, the proposed action is expected to continue impacts on CCV steelhead in the American River with temperatures similar to those experienced over the past 20 years and flows similar to current operations.

Table 73 describes the life stages, primary stressors and effect pathways, and relevant management actions for each operational season on the American River. The purpose of Table 73 is to succinctly summarize the primary consequences of the proposed action without comparison to other scenarios or conditions. These effects that are summarized in Table 73 also will be carried forward to the Integration and Synthesis section of the opinion.

Table 72. Summary of American River long-term operations effects on California Central Valley (CCV) steelhead stressors for adult migration and holding (September to April).

Life Stage (Location)	Life Stage (Timing)	Stressor	Individual Response and Rationale of Effect	Severity of Stressor	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence
Adult Migration and Holding	Sep - Apr	Water temperature	Water temperature and dissolved oxygen impact metabolism and survival	Sub-Lethal	Small	Medium	Low	High
		Pathogens and Disease	Pathogen virulence and prevalence of disease	Sub-Lethal	Large	Medium	Medium	Medium
Adult Spawning	Dec - Apr	Water temperature	Stress on adults and reduced spawning success	Sub-Lethal	Medium	High	Medium	Medium
		Pathogens and disease	Pathogen virulence and prevalence of diseases	Sub-Lethal	Small	Medium	Low	Medium
		Spawning habitat	Decreased spawning habitat	Sub-Lethal	Large	Medium	Low	Medium
Kelt Emigration	Dec - Jun	Water temperature	Changes in metabolism resulting from altered water temperatures	Sub-Lethal	Medium	Medium	Medium	Medium
		Pathogens	Pathogen virulence and prevalence of disease	Sub-Lethal	Medium	Medium	Low	Medium
Eggs Incubation to Fry Emergence	Dec - May	Stranding and dewatering	Mortality of incubating eggs due to desiccation	Sub-Lethal	Medium	High	Medium	Medium
		Water temperature	Water temperature and dissolved oxygen impact metabolism and survival	Sub-Lethal	Medium	High	Medium	High
		Pathogens and Disease	Pathogen virulence and prevalence of disease.	Sub-Lethal	Small	Medium	Low	Medium
Juvenile Rearing to	Year Round	Stranding risk	Increased mortality of trapped juveniles in habitat disconnected from the main stem.	Lethal	Medium	High	High	High

Life Stage (Location)	Life Stage (Timing)	Stressor	Individual Response and Rationale of Effect	Severity of Stressor	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence
Out-migration		Out-migration cues	The proposed storage of water may increase the out-migration cue stressor.	Sub-Lethal	Large	High	Medium	High
		Water temperature and Dissolved Oxygen	Water temperature and dissolved oxygen impact metabolism and survival	Sub-Lethal	Large	Medium	Medium	Medium
		Pathogens and disease	Pathogen virulence and prevalence of disease	Sub-Lethal	Large	High	High	Medium
		Refuge habitat	Decreased flows in the American River thereby reducing suitable margin and off-channel habitats available as refuge habitat for juveniles.	Sub-Lethal	Medium	Medium	Medium	Medium
		Food availability and quality	Decreased quality and quantity of food due to flow alterations for foraging juvenile CCV steelhead will impact growth rates. Additionally, food limitation can weaken juvenile CCV steelhead, leading to extremes such as starvation, and alter behavior resulting in predation risk.	Sub-Lethal	Medium	Medium	Medium	High

Table 73. California Central Valley steelhead summary of primary affected life stages, primary stressors/effect pathways, and relevant management actions for seasonal operations periods. These are the elements that will be incorporated into the Integration and Synthesis section of the opinion.

Division/ Waterbody	Seasonal Operations Period	Affected Life Stage	Summary of Primary Stressors and Effects of the Proposed Action	Relevant Management Actions
American River	Summer and Fall Operations	Juvenile Rearing	Water temperature ● Summer temperatures range from 63°F to 72°F at Watt Avenue and 50% of months across all years exceed threshold for increased virulence and susceptibility to disease	Minimum instream flows/minimum release requirement, water temperature management
			Stranding Risk ● Summer and fall flow fluctuations strand individuals	Minimum instream flows/minimum release requirements, water temperature management
		Adult Migration	Water Temperature ● 16% of months have temperatures that impair/block adult upstream migration at Watt Avenue, 2% of months block migration at Hazel Avenue ● 38% to 45% of months water temperatures exceed thresholds that increase virulence and susceptibility to disease	Minimum instream flows/minimum release requirements, water temperature management
	Winter and Spring Operations	Juvenile Rearing	Stranding Risk ● Winter and spring flow fluctuations strand individuals, especially from March and April	Minimum instream flows/minimum release requirement, water temperature management
			Water temperature ● Threshold for smoltification exceeded 41% of months at Watt Avenue and 20% of months at Hazel Avenue	Minimum instream flows/minimum release requirement, water temperature management
		Spawning Adults	Spawning Habitat ● Flows and habitat support up to 150 acres of spawning habitat	Minimum instream flows/minimum release requirements, water temperature management

Division/ Waterbody	Seasonal Operations Period	Affected Life Stage	Summary of Primary Stressors and Effects of the Proposed Action	Relevant Management Actions
			Water Temperatures ● Exceed targets 4% of months at Hazel Avenue and 9% of months at Watt Avenue.	Minimum instream flows/minimum release requirements, water temperature management
		Incubating Eggs	Redd Dewatering ● Large flow fluctuations cause dewatering mainly between January and March	Minimum instream flows/minimum release requirements, water temperature management
			Water Temperature ● 43% to 55% of months outside of optimal range for egg incubation at Hazel Avenue and Watt Avenue. ● Increasing egg stress and mortality at Watt Avenue beginning in March as average temperature exceeds 54°F ● Increasing egg stress and mortality at Watt Avenue beginning in mid-April as average temperature exceeds 54°F	Minimum instream flows/minimum release requirements, water temperature management

7.3.2. Effects of the Action on Critical Habitat

The Lower American River is designated as critical habitat for CCV steelhead. The essential PBFs of critical habitat in the Lower American River include freshwater spawning sites, freshwater rearing areas, and freshwater migration corridors. This analysis on the effects of the proposed action on CCV steelhead critical habitat is based on information presented in preceding sections regarding its effects to CCV steelhead, and the effects are summarized below as they relate to the PBFs of critical habitat. As effects to individual fish are intrinsically linked to what life stage is present at the time of the exposure and the condition of the habitat to support that life stage, we use the species effects analysis conclusions (exposure and response), as the foundation for our analysis of effects to critical habitat. For example, as effects of riparian removal on rearing juveniles are likely to result in reduced growth/survival, the effects to critical habitat would be described in terms of the PBFs affected for that life stage, thereby resulting in degraded rearing habitat.

Although there is some improvement in the proposed action compared to the NAA, spawning and rearing PBFs in the American River are still expected to be negatively affected by flow and water temperature conditions associated with the proposed action. Elevated water temperatures can degrade spawning habitat for those CCV steelhead that spawn later in the season (e.g., March), or farther downstream (e.g., at Watt Avenue), leading to reduced productivity. For example, under the proposed action, the percent of months during the December through March period outside the 45°F to 55°F water temperature range for successful CCV steelhead spawning at Watt Avenue averaged 9 percent across all water year types and 25 percent during critical years (Table 22 in U.S. Bureau of Reclamation 2023-2024). During critical years, water temperatures at Watt Avenue can experience substantial warming, potentially making the habitat unsuitable for CCV steelhead reproductive success. Average temperatures can increase by 5°F, rising from 52°F in February to 57°F in March. This warming trend surpasses the upper threshold of the optimal temperature range (45°F to 55°F) required for successful CCV steelhead spawning habitat (Table F.2.11-14-6b in U.S. Bureau of Reclamation 2023-2024). There is also a potential for reduced diversity in life history timing by truncating the timing and area available for successful spawning. Consequently, reduced suitability of habitat due to elevated water temperatures during some months of the spawning season can result in degradation or depletion of spawning PBFs for CCV steelhead critical habitat.

High flows during flood control operations expected under the proposed action can affect CCV steelhead spawning habitat by mobilizing gravels. Flows can support the distribution of augmented gravel by mobilizing gravel and redistributing it throughout the river. This can help to create new spawning habitat and improve the quality of existing habitat. For example, high flows can transport augmented gravel from upstream areas to downstream areas, where it can be used by spawning salmonids. Flows can also help to prevent armoring and sedimentation of gravel by removing fine sediment that can clog the spaces between gravel particles. In the Lower American River, roughly 24 acres have been devoted to gravel augmentation through the CVPIA (U.S. Bureau of Reclamation 2023-2024) and flows can help to make this gravel more useful for spawning habitat. Conversely, decreased spawning gravel availability during the spawning season can result in degradation or depletion of spawning PBFs for CCV steelhead critical habitat. Spawning bed materials in the Lower American River may begin to mobilize at flows of 30,000 cfs, with more substantial mobilization occurring at flows of 50,000 cfs or greater (Ayres

Associates 2001). Flood frequency analysis for the American River at Fair Oaks gauge shows that, on average, flows will exceed 30,000 cfs about once every 4 years and exceed 50,000 cfs about once every 5 years. A flood frequency analysis by National Marine Fisheries Service (2018a) found that in 33 percent of years flows will exceed 30,000 cfs, with 11 percent of years having multiple flow events exceeding 30,000 cfs.

Spawning and rearing habitat PBFs in the Lower American River are negatively affected by flow fluctuations, which can result in redd dewatering and isolation, fry stranding, and juvenile isolation. These relatively warm water temperatures also increase the susceptibility of juvenile CCV steelhead to predation due to both increased predator abundance and increased digestion and consumption rates of these predators associated with higher water temperature (Vigg and Burley 1991, Vigg et al. 1991).

The proposed action is expected to still present temperature stresses to early life stages and therefore the spawning and rearing habitat PBFs. The highest frequency of exceedances were both at Watt Avenue, where 55 percent of the months were above the egg incubation temperature range and 50 percent were above the juvenile rearing and out-migration pathogens threshold (Table 45 and Table 63 in U.S. Bureau of Reclamation 2023-2024).

Based on the above discussion, the values of spawning, rearing, and migratory habitat PBFs for the conservation of the species are negatively affected as a result of the proposed action. Table 74 summarizes the effects of the action on critical habitat.

7.3.2.1. Summary of Effects of the Action on Critical Habitat

Table 74. American River summary of effects of the action on critical habitat of California Central Valley (CCV) steelhead.

Species	Life Stage	Action Component	Location of Effect	Physical and Biological Features (PBFs) Affected	Response and Rationale of Effect	Magnitude of Effect	Weight of Evidence
CCV steelhead	Spawning Adults, Incubation of Eggs, and Rearing for Fry	Flow and Water Temperature Management	American River from Nimbus Dam to Watt Avenue	Freshwater Spawning Sites	Spawning temperatures are suboptimal with exceedances anticipated under the proposed action	Medium	Medium
	Freshwater Rearing Habitat for Juveniles		American River from Nimbus Dam to the Sacramento River	Freshwater Rearing Sites	Exceedance of water temperature objectives degrades juvenile rearing habitat	High	Medium
	Freshwater Migratory Corridor PBFs for Out-migrating Juveniles and Spawning Adults			Freshwater Migration Corridors	7% decrease in the percent of months above the lethal water temperature limit for adult CCV steelhead migration in the American River at Watt Avenue but also 1% increase in the same metric at Hazel Avenue; 5% decrease in the percent of months above the adult pathogen susceptibility threshold at Hazel Avenue	Medium	Medium

7.4. East Side Division

7.4.1. Effects of the Action on Species in the Stanislaus River

As described in Section 3.8 of the BA (U.S. Bureau of Reclamation 2023-2024), Reclamation operates and maintains the East Side Division of the CVP year-round, where seasonal operations provide for flood control, municipal, industrial and agricultural water supplies, hydroelectric power generation, fish and wildlife protection, recreation, and water quality. Reclamation's facilities include the New Melones Dam, Reservoir (2.4 MAF capacity), and Powerplant.

Through the partnership between the Oakdale Irrigation District and South San Joaquin Irrigation District, the Tri-Dam Project consists of Donnells and Beardsley dams, located upstream of New Melones Reservoir on the middle fork Stanislaus River, and Tulloch Dam and Powerplant, located approximately 6 miles downstream of New Melones Dam on the mainstem Stanislaus River. Releases from Donnells and Beardsley dams affect inflows to New Melones Reservoir. The main water diversion point on the Stanislaus River is Goodwin Dam, an impassable barrier for fish migration approximately 2 miles downstream of Tulloch Dam (Figure 100).

In general, dam operations (e.g., CVP's New Melones Dam) will alter the downstream hydrograph relative to the unimpaired hydrograph. The most notable difference is the reduction in annual peak flows due to the capture of winter and snowmelt flood flows and the somewhat higher summer flows mediated by reservoir releases. Schneider et al. (2000) summarized the relative flattening of the hydrograph after construction of New Melones Dam, in both wet and dry years. In wet year conditions, annual peak flows of 25,000 cfs to 30,000 cfs were reduced to less than 5,000 cfs. In dry year conditions, annual peak flows of 7,000 cfs to 8,000 cfs were reduced to less than 1,500 cfs (Schneider et al. 2000, Kondolf et al. 2001).

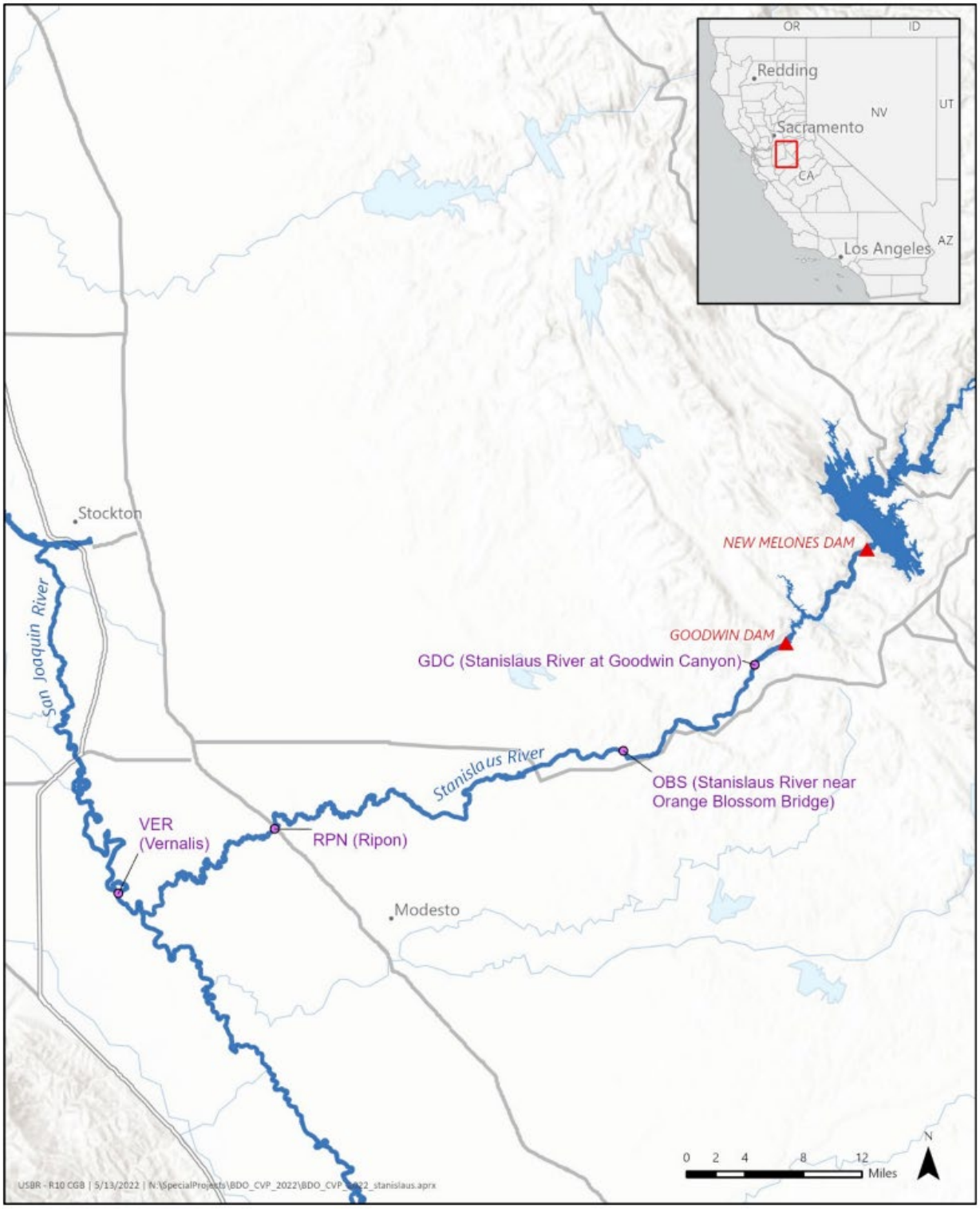


Figure 100. Area map of key locations in the East Side Division.

Source: (U.S. Bureau of Reclamation 2023-2024)

Using the description of the East Side Division provided by Reclamation, NMFS deconstructed the proposed action to identify the project components (deconstructed action; Figure 101) that would contribute to stressors affecting listed species or affect environmental conditions that may, in turn, affect listed species or their designated critical habitat. In considering those effects on species and critical habitat, NMFS follows effects pathways which begin with the deconstructed action and the identification of its principal components. For the East Side Division (Figure 101), components of the proposed action include those that are within Reclamation's discretion to control, but also includes components that may be changed or refined on an annual basis through real-time operations with the Stanislaus Watershed Team (SWT) to adapt to changing conditions and address other requirements.

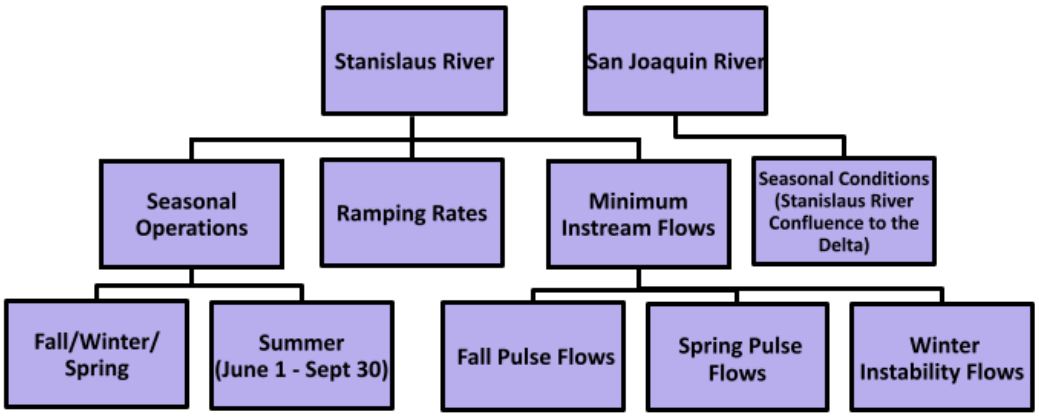


Figure 101. Deconstructed project components in the Stanislaus and San Joaquin rivers (East Side Division).

The project components of the proposed action in the Stanislaus River addressed in this effects analysis fall into the categories of water temperature management and flow management. These categories of management are understood to affect the environmental attributes of dissolved oxygen, food availability and quality, water temperature, pathogens and disease, habitat availability, stranding of fry and dewatering of redds, juvenile migration cues, and entrainment into water diversions (Windell et al. 2017). This analysis focuses on key elements of Reclamation's operation of New Melones Dam, and related dams of the East Side Division (see the map of the Stanislaus River, Figure 100).

7.4.1.1. Modeling Scenarios Considered

The BA modeled several operational scenarios that will be used in this effects analysis: the proposed action without TUCPs (Alt2v1), the NAA, and the obligated releases scenario (EXP3). We used the Alt2v1 modeling scenario to analyze the effects of the proposed action rather than Alt2v2, the proposed action modeling scenario with the 2-year pre-adoption period of the Delta VAs volumetric export reduction. Analysis of the effects of the Alt2v2 scenario did not show substantial differences in flow and temperature for the East Side Division, such that modeling for Alt2v1 and Alt2v2 are virtually indistinguishable outside of the Delta (see Figure 102 and Figure 103).

The effects of the proposed action, Alt2v1, are also presented relative to the NAA and EXP3 modeling. Providing the results relative to the NAA, which is a close, modeling representation of past and present operations is helpful in providing context for the absolute condition, and indicating how the effects of the proposed action differ from the effects of current operations. Results are provided relative to EXP3 to illustrate how Reclamation's discretion is exercised to influence the direction of stressors.

7.4.1.2. Summary of Stanislaus River Stressors

Table 75 provides a summary of those factors analyzed under each proposed action component for the Stanislaus River, which have been adapted for CCV Steelhead and CV spring-run Chinook salmon based on the SAIL conceptual model in the "Scientific framework for assessing factors influencing endangered Sacramento River winter-run Chinook salmon across the life cycle" (Windell et al. 2017). The exposure, and response of CCV steelhead and CV spring-run Chinook salmon to the project-related stressors are then analyzed in the following sections for each proposed action component or sub-component.

Table 75. Stressors/attributes affected by components of the proposed action in the Stanislaus River.

	Water Temperature	Dissolved Oxygen	Juvenile Migration Cues	Pathogens and Disease	Food Availability and Quality	Habitat Availability	Stranding and Dewatering
Seasonal Operations (Fall/Winter/Spring)	X		X	X	X	X	X
Seasonal Operations (Summer)	X	X		X	X	X	
Ramping Rates							X
Minimum Instream Flows			X			X	

7.4.1.3. Seasonal Operations

Effects associated with the Stanislaus River operations are considered to begin downstream of Goodwin Dam, the primary barrier to anadromy in the Stanislaus River. Under the proposed action, seasonal releases from Goodwin Dam into the Stanislaus River will be made according to the Stanislaus River SRP of the proposed action (Alt2v1 modeling scenario described in Appendix N of the BA). This includes operations that meet minimum flows (i.e., EXP3), that address flood control, reservoir storage management, and other regulatory requirements.

Seasonal operations are largely managed by Reclamation through Governance, which includes two main coordination forums that will meet regularly to discuss seasonal and real-time operations. These include the WOMT and the Stanislaus Watershed Team (SWT). The SWT is a technical group that discusses reservoir and storage planning, forecasting and seasonal operations, flow and water temperature management, and monitoring programs. The SWT will coordinate with other groups as appropriate. East Side-Stanislaus River Governance will use a collaborative approach to planning and decision-making. Governance describes that the groups will strive to reach consensus; if consensus cannot be reached, group members may elevate to the next higher level for resolution. Agency directors may reserve final decision making for matters under their respective authority.

7.4.1.3.1. Fall/Winter/Spring

In the fall, winter, and spring, Reclamation primarily operates to the non-discretionary obligations of D-1641 and flood control in accordance with the USACE Standard Operation and Maintenance Manual for the Lower San Joaquin River Levees Lower San Joaquin River and Tributaries Project, California (April 1959). As a general rule, Reclamation seeks to minimize potential redd dewatering, redd scouring, and juvenile stranding for CCV steelhead. Also, at times during the winter and spring seasons, Tulloch Lake may be in flood control operations for brief periods even when New Melones Reservoir is not. During these periods, releases from Tulloch Lake may be used to meet flow objectives, schedules, or requirements on the Lower Stanislaus River below Goodwin Dam.

Although the primary objectives of fall, winter, and spring operations apply year-round, the objectives of flood control and the downstream objectives of D-1641 are potentially constraining from October to May. In this period, operations may affect the adult, egg, and juvenile life stages of CCV steelhead in the Stanislaus River. During the fall, winter and spring seasonal operations of the East Side Division, proposed action components are understood to affect the environmental drivers and conditions related to the temperature and hydrology of the river. Stressors associated with these environmental attributes, and at this time of year, include:

- **Water Temperature**, which in turn may influence the pathogens and disease stressor and juvenile migration cues
- **Flow Conditions**, which affect spawning and rearing habitat availability, stranding and dewatering, juvenile migration cues, and food availability and quality

7.4.1.3.1.1. Water Temperatures

Figure 102 shows the generalized temperature patterns of the different scenarios as modeled by HEC-5Q, which highlights the pattern of warmer water temperatures in the summer and fall months and cooler water temperatures in the fall, winter, and spring.

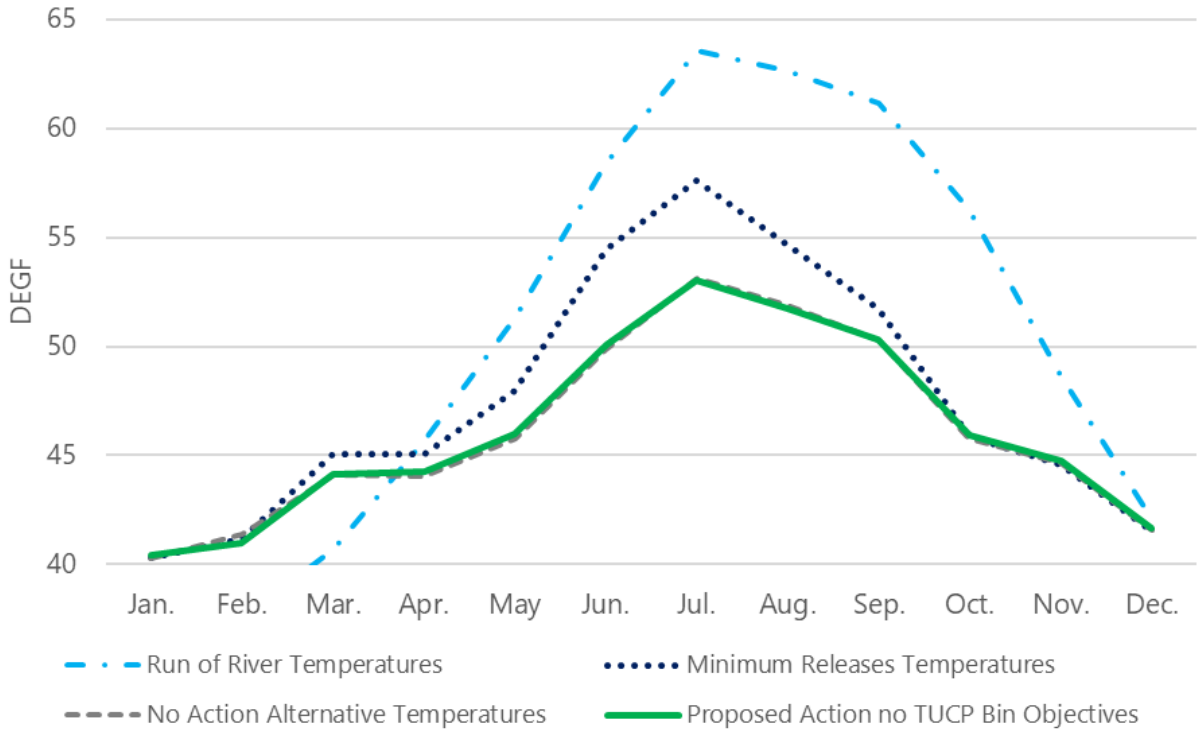


Figure 102. HEC-5Q modeled temperatures (°F) at Orange Blossom in the Stanislaus River.

Source: (U.S. Bureau of Reclamation 2023-2024)

EPA (2003) provides the most comprehensive set of water temperature standards, which are used here to identify the thresholds against which the performance of a particular operation scenario is measured. Unless otherwise cited in the East Side Division effects analysis, the temperature thresholds and ranges described below come from Table 1 of EPA (2003). Water temperatures within the range of 69.8°F to 71.6°F have been shown to either block or delay adult steelhead migration or were lethal with prolonged (1 week) exposure. Prolonged exposure to temperatures starting at and above 62.6°F would be expected to cause a reduction in migration fitness due to cumulative stress. Holding adults exposed to temperatures at or above 55.4°F would experience a reduction in gamete viability, potentially reducing the productivity of the spawning population. Increased temperatures will also affect the relative susceptibility to disease and pathogens with an elevated risk to adults at temperatures above 57.2°F.

Successful steelhead spawning occurs at temperatures between 45–55°F (Bell 1991, Richter and Kolmes 2005), which is consistent with the temperature range of 39.2–57.2°F identified in the EPA Region 10 Guidance (EPA 2003). Steelhead egg incubation temperatures are optimal between 45–52°F (McCullough et al. 2001). Reclamation proposes to use the upper threshold egg incubation temperature of 54°F identified in Section 4.1 of Appendix N - Stanislaus SRP (U.S. Bureau of Reclamation 2023-2024).

Juvenile CCV steelhead are susceptible to high water temperatures as well. Water temperatures within the range of 53.6°F to 59°F have been shown to impair smoltification in juveniles, while prolonged exposure (1 week) to temperatures in the range of 73.4°F to 78.8°F are considered

lethal (EPA 2003). Increased temperatures will also affect the relative susceptibility of juvenile CCV steelhead to disease and pathogens with an elevated risk at temperatures above 57.2°F.

Exposure

Adult CCV steelhead migrate into the San Joaquin River watershed starting in September and continuing through March. As there is a considerable coincidence of adult CCV steelhead migration and holding with fall, winter and spring operations (October–March), the potential proportion of the population exposed is large (70 percent or more exposed).

CCV steelhead spawning and egg incubation occurs between the months of December and June. The entirety of CCV steelhead spawning and egg incubation coincides with fall, winter, and spring operations (December–May), which constitutes a large proportion (70 percent or more) exposed.

Juvenile CCV steelhead may be found rearing in the upper reaches of the Stanislaus River year-round (Stanislaus River Scientific Evaluation Process (SEP) Team 2019). A summary of Oakdale rotary screw trap data indicates that about 80 percent of juvenile CCV steelhead are captured in the months of October through May (Eschenroeder et al. 2022). As with other CCV steelhead life stages, fall, winter, and spring seasonal operations coincide with a large proportion (70 percent or more exposed) of the juvenile migration.

Response

Steelhead response to elevated water temperatures varies in severity according to the life stage affected. For adult CCV steelhead migrating or holding, temperatures above 62.6°F would result in a minor effect of reduced migration fitness. Meanwhile, prolonged exposure to temperatures at or above 55.4°F would reduce gamete viability, potentially reducing the spawning success of the population. Temperatures above 57.2°F will also affect the relative susceptibility of adults to disease and pathogens. Incubating eggs and emergent fry are also susceptible to elevated water temperatures where a temperature threshold of 54°F has been identified on the Stanislaus River (Appendix N - Stanislaus SRP in U.S. Bureau of Reclamation 2023-2024), above which temperatures would be expected to be lethal. Juvenile steelhead in the Stanislaus River exposed to temperatures in the range of 53.6°F to 59°F will experience impaired smoltification (EPA 2003), where Reclamation considered a midpoint water temperature threshold of 55°F as the limit of successful smoltification at Orange Blossom Bridge. Reclamation's analysis in the BA evaluated the potential effects of operations under the proposed action on the water temperature stressor by assessing how often modeled water temperatures exceeded the following thresholds: the upper limit of optimal growth without food limitation of 66.2°F identified by Myrick (1998) and Myrick and Cech Jr (2001), and the water temperature threshold above which pathogen virulence is expected to increase (59.9°F, McCullough 1999).

The response associated with the exposure to each stressor is assessed as the cumulative proportion of a month where a particular temperature threshold is met or exceeded. Reclamation's analysis of Stanislaus River temperatures (Appendix N_Attachment N in U.S. Bureau of Reclamation 2023-2024) provides a robust temperature analysis of the frequency with which life stage specific temperature thresholds are exceeded by month and water year type.

When looking at the effects of the proposed action, for adults in the Stanislaus River (Orange Blossom Bridge), the proportion of months during which adult CCV steelhead are migrating or holding in all year types and where temperatures are at or above Reclamation's threshold for migration impairment (66.2°F) is only about 3.0 percent of Octobers in critically dry years based on HEC-5Q modeling (Appendix N_Attachment N in U.S. Bureau of Reclamation 2023-2024). Since Reclamation's threshold for migration impairment is higher (66.2°F) than that described by EPA (2003) at 62.6°F, NMFS expects the risk to be higher than the 3.0 percent of Octobers in critically dry years described by modeling, but that this still constitutes a low-level risk (i.e., infrequent; occurring in fewer than 25 percent of years). Likewise, Reclamation assessed the potential impacts posed by lethal water temperatures at or above 69.8°F, which modeling identified as having a 0.0-percent chance of occurrence during the adult migration period. The risk of temperature induced reduction in gamete viability, which begins at temperatures at or above 55.4°F, was not included in the BA, but Reclamation did assess the frequency of temperatures exceeding 55°F December–May. Of the months modeled and for which CCV steelhead adults would be expected to be migrating or holding, about 10.5 percent of months in all year types would be expected to have temperatures above 55°F under the proposed action, which constitutes a low-level risk (i.e., infrequent; occurring in fewer than 25 percent of years).

Reclamation also assessed the potential impacts to CCV steelhead eggs caused by the increased water temperature consequence of the proposed action. Using a temperature threshold of 54°F (Appendix N - Stanislaus SRP in U.S. Bureau of Reclamation 2023-2024), above which temperatures would be expected to be lethal to eggs, Reclamation assessed the percent of months above the threshold by month and water year type (using the San Joaquin Valley Index), in the Stanislaus River at Orange Blossom Bridge, from December through May (Table 76). Based on Reclamation modeling, a summary of the risk of increased temperatures in the months of fall, winter and spring seasonal operations when CCV steelhead eggs would be expected to be incubating is about 49 percent of months for the proposed action, a medium level risk (i.e., moderately frequent; occurring in 25 to 75 percent of years).

Table 76. Percent of months above the 54°F value for California Central Valley steelhead egg incubation by water year type (San Joaquin Valley Index) and month and for all years combined, in the Stanislaus River at Orange Blossom Bridge, from December through May.

Water Year Type	Month	Proposed Action Alt2v2	Proposed Action Alt2v1	NAA	EXP3
All	Dec.	26.5	26.5	24.5	22.4
All	Jan.	6.1	6.1	6.1	7.1
All	Feb.	20.4	20.4	24.5	24.5

Water Year Type	Month	Proposed Action Alt2v2	Proposed Action Alt2v1	NAA	EXP3
All	Mar.	74.5	73.5	71.4	65.3
All	Apr.	72.4	72.4	67.3	73.5
All	May	93.9	93.9	95.9	96.9
Average	Dec - May	49.0	48.8	48.3	48.3

Source: (U.S. Bureau of Reclamation 2023-2024)

When looking at the effects of the proposed action, Reclamation assessed the potential risk associated with elevated temperatures in the Stanislaus River that can affect juvenile CCV steelhead through different mechanisms, which may limit growth (66.2°F upper optimal limit of growth without food limitation), impair smoltification (55°F limit of successful migration cue), and affect susceptibility to disease (59.9°F pathogen virulence threshold). Based on Reclamation's modeling, a summary of the potential adverse impacts associated with the occurrence of temperatures above the optimal growth threshold and in the months of fall, winter, and spring seasonal operations (October–May) is on average 2.3 percent of months for the proposed action. The modeling of the proposed action scenario is considered to have an overall low likelihood (i.e., infrequent; occurring in fewer than 25 percent of years) of temperatures exceeding the 66.2°F upper optimal limit of growth without food limitation (Table 77).

Reclamation modeling also considered the percent of months above the 55°F successful smoltification water temperature limit for CCV steelhead by water year type (San Joaquin Valley Index) and month, and for all years combined, at Orange Blossom Bridge, January through May (see Table 77). Overall, modeling showed the average percent of months during the typical juvenile migration period (January–May) that exceeded the 55°F successful smoltification water temperature limit for CCV steelhead was about 27 percent for the proposed action, a medium level risk (i.e., moderately frequent; occurring in 25 to 75 percent of years).

Lastly, Reclamation considered the percent of months above the 59.9°F pathogen virulence water temperature threshold for juvenile CCV steelhead rearing and out-migration by water year type (San Joaquin Valley Index) and month, and for all years combined, at Orange Blossom Bridge. This modeling showed that the average risk of exceeding the 59.9°F pathogen virulence water temperature threshold at Orange Blossom Bridge during fall, winter and spring seasonal operations (October–May) is only about 1 percent of months for the proposed action.

Table 77. Percent of months above the 66.2°F value for California Central Valley (CCV) steelhead optimal growth threshold October through May (a) and the 55°F value for CCV steelhead successful smoltification,

January through May (b), by water year type (San Joaquin Valley Index) and month and for all years combined, at Orange Blossom Bridge.

Water Year Type	Month	Proposed Action Alt2v2	Proposed Action Alt2v1	NAA	EXP3
(a) Percent of months above the 66.2°F October through May					
All	Oct.	2.1	2.1	2.1	6.2
All	Nov.	0	0	0	0
All	Dec.	0	0	0	0
All	Jan.	0	0	0	0
All	Feb.	0	0	0	0
All	Mar.	0	0	0	0
All	Apr.	0	0	0	12.2
All	May	16.3	16.3	11.2	43.9
Average	(October - May)	2.3	2.3	1.7	7.8
(b) Percent of months above the 55°F January through May					
All	Jan.	2	2	1	1
All	Feb.	3.1	3.1	3.1	3.1
All	Mar.	34.7	35.7	36.7	51
All	Apr.	40.8	40.8	34.7	46.9
All	May	53.1	53.1	52	57.1

Water Year Type	Month	Proposed Action Alt2v2	Proposed Action Alt2v1	NAA	EXP3
Average	(January - May)	26.7	26.9	25.5	31.8

Source: (U.S. Bureau of Reclamation 2023-2024)

Table 78 summarizes the water temperature effects of the Fall/Winter/Spring seasonal operations element of the proposed action on CCV steelhead in the Stanislaus River.

Table 78. Information used to identify effects of water temperature on California Central Valley steelhead as a result of East Side Division fall, winter, and spring seasonal operations element of the proposed action in the Stanislaus River.

Stressor	Life Stage (Location)	Life Stage Timing (Work Window Intersection)	Individual Response and Rationale of Effect	Severity of Stressor	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence
Fall, Winter, Spring Seasonal Operations (Water Temperature)	Adult migration and holding	September - March (October - March)	Reduced gamete viability	Minor	Large	Low (10.5%)	Medium	Low
Fall, Winter, Spring Seasonal Operations (Water Temperature)	Egg incubation	December - June (December - May)	Reduced egg survival	Lethal	Large	Medium (49%)	High	Medium
Fall, Winter, Spring Seasonal Operations (Water Temperature)	Juvenile rearing	Year-round (October - May)	Reduced growth	Minor	Large	Low (2.3%)	Low	Low
Fall, Winter, Spring Seasonal Operations (Pathogens and Disease)	Adult migration and holding	September - March (October - March)	Increased susceptibility to pathogens and disease	Sub-lethal	Large	Low (1%)	Low	Low
Fall, Winter, Spring Seasonal Operations (Pathogens and Disease)	Juvenile rearing and migration	Year-round, (October - May)	Increased susceptibility to pathogens and disease	Sub-lethal	Large	Low (1%)	Low	Low

Stressor	Life Stage (Location)	Life Stage Timing (Work Window Intersection)	Individual Response and Rationale of Effect	Severity of Stressor	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence
Fall, Winter, Spring Seasonal Operations (Migration cues)	Juvenile migration	January - May (January - May)	Increased impairment to migration success	Minor	Large	Medium (27%)	Low	Medium

7.4.1.3.1.2. Flow Conditions

Reservoir releases, combined with accretions in the Stanislaus River, contribute to the flow conditions, which are a primary driver for a number of potential stressors. The effects of these stressors follow the effects pathways described in the SAIL conceptual model (Windell et al. 2017), which starts with the flow-based management actions of the proposed action. These effects contribute to a probable change in fitness of reduced growth, reduced survival probability, reduced reproductive success, and/or reduced lifetime reproductive success. Here we refer to flow conditions as the quantity, timing, and quality of water flows. Because a number of other stressors are influenced by flow conditions, the discussion below focuses on the following specific facets: food availability and quality, spawning and rearing habitat availability, redd dewatering, juvenile isolation and stranding, and entrainment (e.g., travel time and out-migration).

Figure 103 shows average monthly releases from Goodwin Dam to the Stanislaus River under different modeling scenarios. The flows that result in each month from the proposed action, as shown in the figure, are considerably different from those to which the species have evolved and it is unclear whether species are adequately adapted to the current conditions and those resulting from the proposed action. Relative to NAA, the proposed action flows are virtually indistinguishable, meaning that the flow conditions of the proposed action will result in effects that are the same as the NAA. Relative to EXP3, flows are generally higher than the proposed action (Alt2v1 in Figure 103) in November through March and slightly higher in August and September. Proposed action release flows tend to be higher than those of the EXP3 modeling scenario in April through July and about the same in the month of October.

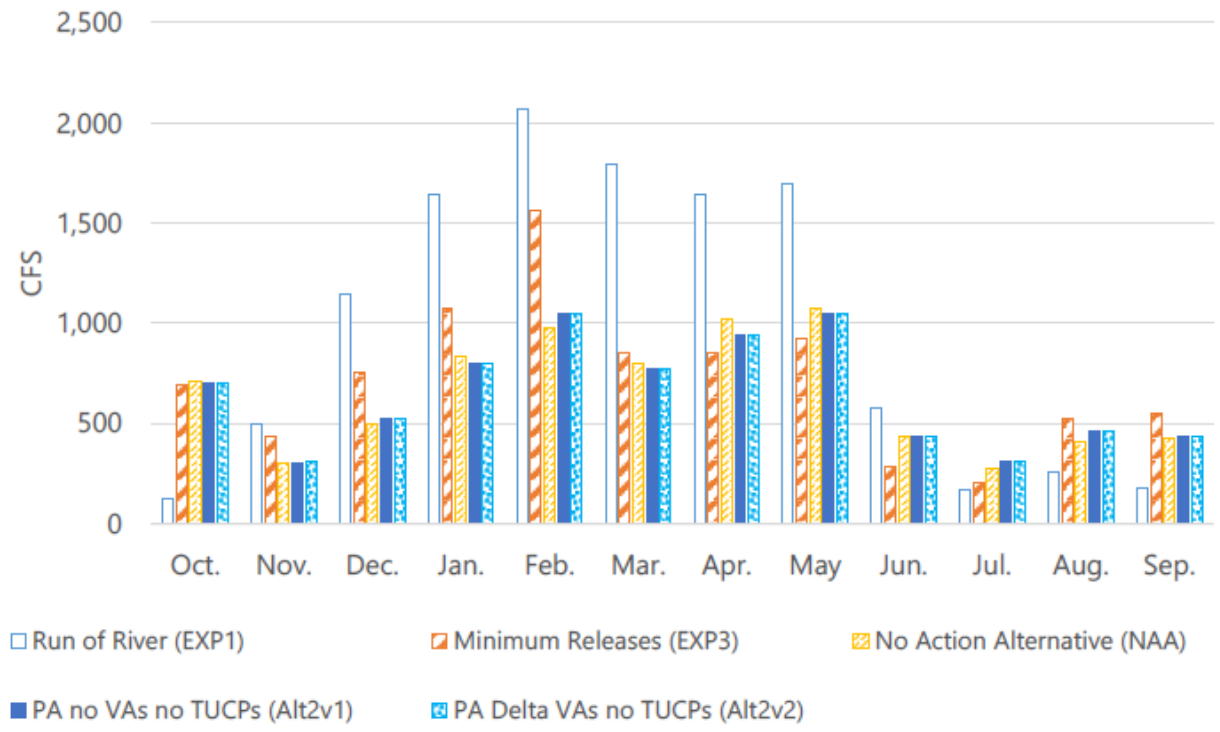


Figure 103. Stanislaus River below Goodwin Dam monthly flows (cubic feet per second), all water year types.

Source: (U.S. Bureau of Reclamation 2023-2024)

Exposure

Adult CCV steelhead migrate into the San Joaquin watershed starting in September and continuing through March. CCV steelhead spawning and egg incubation occurs between the months of December and June. Juvenile CCV steelhead may be found in the upper reaches of the Stanislaus River year-round (Stanislaus River Scientific Evaluation Process (SEP) Team 2019). A summary of Oakdale rotary screw trap data indicates that about 80 percent of juvenile CCV steelhead are captured in the months of October–May (Eschenroeder et al. 2022).

Response

CCV steelhead response to altered flow conditions varies in severity according to the life stage affected and the effects pathway considered. For adult CCV steelhead migrating, holding, and spawning in the Stanislaus River, the effect of the action on individual fish is reflected in the relative change in spawning habitat availability, which is considered here as a surrogate for a change in spawning success. Specifically, the proposed storing and diverting of water may decrease the spawning habitat availability stressor, where during the spawning period, the proposed action will result in decreased flows in the Stanislaus River below Goodwin Dam. There is an apparent inverse relationship of certain higher flows resulting in higher water velocities, and a potential increase of redd superimposition leads to less spawning habitat

suitability (Dudley 2019). Ultimately, the adult CCV steelhead response to an increase in the spawning habitat availability stressor (i.e., a decrease in spawning habitat quantity or quality) is reduced spawning success.

Table 79 shows the spawning WUA for the modeled scenarios for all water year types. The WUA values of the proposed action range from 700,000 to 360,000. Relative to the NAA, WUA of the proposed action is decreased slightly (-2.9 percent) in all water year types. This is not expected to substantially impact spawning conditions for the species present. Relative to EXP3, there is an average increase in access or quality of spawning habitats for the proposed action regardless of water year type.

Table 79. Expected mean Total Weighted Usable Area for California Central Valley steelhead spawning in the Stanislaus River for the proposed action, NAA, and EXP3.

Water Year Type	Proposed Action Alt2v2	Proposed Action Alt2v1	NAA	EXP3
Wet	360,125	360,530	364,959	205,894
Above Normal	414,070	414,070	429,481	236,196
Below Normal	448,814	448,814	460,146	325,043
Dry	645,691	645,747	673,152	449,406
Critical	700,988	701,622	722,916	641,211
All	546,322	546,636	563,238	417,082

Source: (U.S. Bureau of Reclamation 2023-2024)

The effects of changing flow conditions on incubating eggs and emergent fry are primarily reflected in the likelihood that a redd would be dewatered. Fluctuations in flow during the incubation period of salmon eggs have the potential to dewater and expose one or more redds. Dewatering is only of concern if in-stream flows during the incubation period are less than the flow at the time of spawning. When this occurs, the response is an increased risk of mortality. The magnitude of this effect is related to the differences in flows and the particular hydraulic and geomorphic considerations of the spawning area (U.S. Fish and Wildlife Service 2006). To minimize this effect, Reclamation proposes operational ramping rates that will allow for reservoir releases to be made in a manner that can accommodate the monitoring of shallow redds at risk of dewatering.

Flow conditions can affect the juvenile life stage in multiple, interconnected ways. Similar to changes in the spawning habitat availability stressor, the proposed storing and diverting of water

may affect the rearing habitat availability stressor where during the fall, winter, and spring, seasonal operations of the proposed action will result in decreased flows in the Stanislaus River below Goodwin Dam that will alter the extent of habitat inundation and juvenile access. The relative availability of habitat will, in turn, affect the amount and quality of food available to rearing juveniles. Windell et al. (2017) focused on the growth and condition of juveniles as being influenced by the availability of, and access to, riparian habitats that determine food availability and quantity. The change in fitness, measured as growth rate, is dependent on the bioenergetic expenditure to obtain a given food supply. Although growth rate is itself a measure of fitness, it may also influence migration timing and success, where a higher growth rate is associated with earlier smoltification and faster downstream migration in Chinook salmon (Beckman et al. 2007). Ultimately, the inability of juvenile salmonids to meet their metabolic demand and achieve some threshold growth rate may also serve as a strong cue to leave that habitat and migrate downstream, while a satisfactory food supply may induce juveniles to remain in the habitat for a longer duration of time to rear. For species with a resident life history strategy like *O. mykiss*, increased food availability and the ability to attain a large body size in freshwater is associated with an increased prevalence of resident individuals (Sharpe et al. 2007).

Table 80 and Table 81 show the total rearing WUA and area of suitable habitat (ASH), respectively, for the modeling scenarios considered. The WUA values of the proposed action range from 1,211,607 to 1,272,542. Relative to the NAA, WUA of the proposed action is increased in all water year types, on the order of less than 1 percent. This is not expected to substantially impact rearing habitat and food availability for the species present. Relative to EXP3 the WUA of the proposed action is also generally greater, on the order of 22 percent. The ASH values of the proposed action range from 662,022 to 808,569 square feet, with increasing habitat availability coinciding with wetter hydrologies. Relative to the NAA, the ASH of the proposed action is essentially the same in all water year types, with a less than 0.3 percent difference between scenarios. This is not expected to substantially impact rearing habitat availability for the species present. The ASH analysis of the proposed action effects relative to the EXP3 modeling scenarios shows similar but less pronounced results than those of the WUA analysis, with a relative increase of about 8.7 percent in suitable rearing habitat under the proposed action (Table 81).

Table 80. Expected Total Weighted Usable Area for California Central Valley steelhead fry rearing in the Stanislaus River downstream of Goodwin Dam for the proposed action, NAA, and EXP3, by water year type.

Water Year Type	Proposed Action Alt2v2	Proposed Action Alt2v1	NAA	EXP3
Wet	1,273,384	1,272,542	1,269,808	1,181,913
Above Normal	1,258,457	1,258,455	1,246,012	1,091,198
Below Normal	1,258,596	1,258,596	1,242,934	1,024,683

Water Year Type	Proposed Action Alt2v2	Proposed Action Alt2v1	NAA	EXP3
Dry	1,234,865	1,234,875	1,216,600	996,797
Critical	1,211,764	1,211,607	1,185,812	884,748
All	1,246,830	1,246,593	1,230,704	1,021,100

Source: (U.S. Bureau of Reclamation 2023-2024)

Table 81. Expected Area of Suitable Habitat for California Central Valley steelhead fry rearing in the Stanislaus River downstream of Goodwin Dam for the proposed action, NAA, and EXP3, by water year type. Values are shown in units of square feet.

Water Year Type	Alt2v2	Alt2v1	NAA	EXP3
Wet	808,577	808,569	817,641	795,186
Above Normal	751,143	751,143	751,684	719,024
Below Normal	736,986	736,989	746,047	680,994
Dry	677,144	677,138	690,220	606,314
Critical	662,037	662,022	651,652	571,623
All	718,892	718,884	721,002	660,957

Source of information: (U.S. Bureau of Reclamation 2023-2024)

Lastly, increases in flow will provide temporary access to habitats that may later become disconnected as managed flows recede. If those habitats become disconnected from the mainstem river channel too quickly they can result in the stranding of juvenile fish. The likelihood of stranding itself may be slight, however, as observed in the Cosumnes River, where few fry were found in stranded off-channel areas where they had been commonly observed during periods of connectivity with the main channel, suggesting fry may be behaviorally adapted to evacuate potential stranding areas (Moyle et al. 2007). Ultimately, fall, winter, and spring seasonal operations will cause changes in the downstream flow condition that may affect

the juvenile stranding and redd dewatering stressor in the Stanislaus River. However, the ramping rates identified in the proposed action have been developed such that the changes in flow will provide time enough to monitor redds for dewatering and to allow juvenile egress from potentially disconnected habitats (Bradford 1997).

For the proposed action the difference in flow conditions and subsequent effects associated with fall, winter and spring seasonal operations is consistently positive for all years, across all water year types. Table 79, Table 80, and Table 81 show WUA and ASH results for the modeled scenarios. Given the opportunity cost of habitat use (i.e., an individual can only spawn or rear in a single location at any given time) the relative increase or decrease in habitat availability serves as a surrogate for the likelihood of using that habitat. Reclamation's presentation of CCV steelhead spawning habitat WUA shows a 2.9 percent decrease in spawning habitat relative to the NAA, but a 31 percent increase in spawning habitat relative to EXP3. Similarly, Reclamation's analysis of CCV steelhead rearing habitat shows that, relative to the NAA, the proposed action increases rearing habitat WUA by less than 1 percent. Relative to EXP3, the proposed action increases rearing habitat WUA by 22 percent. The ASH analysis showed a similar but less pronounced (8.7 percent) increase in area of suitable habitat for CCV steelhead rearing under the proposed action relative to the EXP3 modeling scenario.

Table 82 summarizes the flow effects of the Fall/Winter/Spring seasonal operations element of the proposed action on CCV steelhead in the Stanislaus River.

Table 82. Information used to identify effects of flow condition on California Central Valley steelhead as a result of East Side Division fall, winter, and spring seasonal operations element of the proposed action in the Stanislaus River.

Stressor	Life Stage (Location)	Life Stage Timing (Work Window Intersection)	Individual Response and Rationale of Effect	Severity of Stressor	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence
Fall, Winter, Spring Seasonal Operations (Spawning Habitat)	Adult spawning	September - March (October - March)	Increased spawning habitat availability	Low (increase)	Large	Medium (31%)	Medium	High
Fall, Winter, Spring Seasonal Operations (Dewatering)	Egg incubation	December - June (December - May)	Reduced egg survival (mitigated by ramping rates)	Lethal	Large	Low	Low (Mitigated)	Low
Fall, Winter, Spring Seasonal Operations (Rearing Habitat)	Juvenile rearing	Year-round, (October - May)	Increased rearing habitat availability	Low (increase)	Large	Low (9 to 22%)	Low	High
Fall, Winter, Spring Seasonal Operations (Stranding)	Juvenile rearing	Year-round, (October - May)	Reduced juvenile survival (mitigated by ramping rates)	Lethal	Large	Low	Low (Mitigated)	Low

7.4.1.3.2. Summer

In the summer, Reclamation operations maintain the D-1422, 7.0 milligrams per liter (mg/L) dissolved oxygen requirement on the Lower Stanislaus River (Ripon) for species protection. The dissolved oxygen requirement applies year-round, but is most often controlling water operation decisions from June 1 to September 30, requiring additional releases from Goodwin Dam.

Summer seasonal operations of the East Side Division proposed action elements are understood to affect the environmental drivers and conditions related to the temperature and hydrology of the river. Stressors associated with these environmental attributes and at this time of year include:

- **Water Temperature**, which in turn may influence the pathogens and disease stressor and interact with the dissolved oxygen stressor
- **Flow Condition**, which affects rearing habitat availability, and is used to manage dissolved oxygen compliance

7.4.1.3.2.1. Water Temperature

Figure 102 shows the generalized temperature patterns of the proposed action as modeled by HEC-5Q, which highlights the pattern of warmer water temperatures in the summer and fall months and cooler water temperatures in the fall, winter and spring.

In the months of summer operations (June–September), holding adults may be exposed to temperatures at or above 55.4°F where they would experience a reduction in gamete viability, potentially reducing the productivity of the spawning population. Increased temperatures will also affect the relative susceptibility to disease and pathogens with an elevated risk to adults at temperatures above 57.2°F. Summer seasonal operations also coincide with the tail end of CCV steelhead egg incubation such that there may still be eggs or emergent fry present in the month of June. Egg incubation temperatures are most optimal between 45°F and 52°F (McCullough et al. 2001), with an upper threshold temperature of 54°F established in the SRP (Appendix N in U.S. Bureau of Reclamation 2023-2024).

Juvenile CCV steelhead rear in the Stanislaus River year-round and are susceptible to high water temperatures. Water temperatures within the range of 53.6°F to 59°F have been shown to impair smoltification in juveniles, while prolonged exposure (1 week) to temperatures in the range of 73.4°F to 78.8°F are considered lethal (EPA 2003). Increased temperatures also affect the relative susceptibility of juvenile CCV steelhead to disease and pathogens with an elevated risk at temperatures above 57.2°F.

Exposure

There is considerable overlap of adult CCV steelhead holding (April–September) with summer operations (June–September) where the potential proportion of the population exposed is large (70 percent or more exposed). CCV steelhead spawning and egg incubation typically occurs from December to June. Juvenile CCV steelhead may be found rearing in the upper reaches of the Stanislaus River year-round (National Marine Fisheries Service 2014b, Stanislaus River Scientific Evaluation Process (SEP) Team 2019). A summary of Oakdale rotary screw trap data

indicates that about 80 percent of migrating juvenile CCV steelhead are captured in the months of October–May, suggesting that a rearing juvenile CCV steelhead would be present during summer seasonal operations (Eschenroeder et al. 2022). Likewise, surveys of juvenile salmonid rearing in the Stanislaus River (2002–2004 and 2005–2007) show fairly consistent juvenile densities in the lower river year-round, but with the highest juvenile densities (near Goodwin) from June through December (Kennedy and Cannon 2005, Kennedy 2008). Given the relatively high species density in the upper river during summer months, as well as the observed core migration that occurs late-fall through spring, it is expected that summer seasonal operations coincide with a medium proportion of the juvenile life stage.

Response

CCV steelhead response to elevated water temperatures varies in severity according to the life stage affected. For adult steelhead holding, prolonged exposure to temperatures at or above 69.8°F would result in an increased mortality (Coutant 1970, EPA 2003). Temperatures above 57.2°F will also affect the relative susceptibility of adults to disease and pathogens. Incubating eggs and emergent fry are also susceptible to elevated water temperatures where a temperature threshold of 54°F has been established on the Stanislaus River (Appendix N - Stanislaus SRP in U.S. Bureau of Reclamation 2023-2024), above which temperatures would be expected to be lethal, reducing egg survival. For juvenile CCV steelhead remaining in the Stanislaus River during the summer, prolonged exposure to temperatures at or above 68°F is considered lethal (SRP juvenile rearing metric; Appendix N - Stanislaus SRP in U.S. Bureau of Reclamation 2023-2024). Reclamation also considered the upper optimal limit of growth without food limitation of 66.2°F (Myrick 1998, Myrick and Cech Jr 2001) a minor response of reduced growth, and the water temperature threshold above which pathogen virulence is expected to increase (59.9°F; McCullough 1999) a sublethal effect.

There is also an antagonistic relationship between water temperature and dissolved oxygen concentration where increasing water temperatures are found to have decreasing dissolved oxygen concentrations. Rearing salmonids appear to exhibit no negative effects at average dissolved oxygen levels of 9 mg/L (Davis 1975) but start to exhibit reduced swimming speeds below this threshold when water temperatures are near 68°F (Dahlberg et al. 1968), potentially reducing steelhead swimming speed and increasing juvenile *O. mykiss* vulnerability to predation and competition.

The relative risk associated with each stressor's effect is assessed as the cumulative proportion of a month where a particular temperature threshold is met or exceeded. Reclamation's analysis of Stanislaus River temperatures (Appendix N_Attachment N in U.S. Bureau of Reclamation 2023-2024) provides a robust temperature analysis of the frequency with which life stage specific temperature thresholds are exceeded by month and water year type.

We assessed the potential adverse impacts posed by lethal water temperatures associated with the proposed action, at or above 69.8°F, which modeling identified as having a 0.0-percent chance of occurrence in the holding period coinciding with summer seasonal operations (June–September). Therefore, the proposed action is not expected to reach lethal temperatures for adults of the

species. Water temperatures will also influence the susceptibility of adult CCV steelhead to pathogens and disease, the risk of which Reclamation assessed based on a 59.9°F temperature threshold. Reclamation's analysis of the proposed action indicates that, on average, about 75 percent of months of the summer seasonal operations during the adult holding period (i.e., June–September) would be expected to have temperatures greater than 59.9°F, which would result in increased pathogen virulence (Table 83). Relative to the NAA, the proposed action effects are expected to occur at about the same frequency where the proposed action will decrease the instance of temperatures being above this threshold by 0.6 percent in these months. Relative to EXP3, the proposed action reduces, by 8 percent, the frequency that temperatures exceed this threshold. In assessing the risk to adults posed by holding temperatures that would increase potential pathogen virulence, the proposed action would result in a 75 percent chance of occurrence, which is considered a medium to high level of risk (i.e., moderately frequent; occurring in 25 to 75 percent of years).

Table 83. Percent of months above the 59.9°F value for increased pathogen virulence for each month (June–September) across all water years, Stanislaus River at Orange Blossom Bridge.

Water Year Type	Month	Proposed Action Alt2v2	Proposed Action Alt2v1	NAA	EXP3
All	June	54.1	55.1	54.1	76.5
All	July	96.9	98	99	100
All	Aug.	85.7	86.7	89.8	83.7
All	Sept.	64.3	64.3	63.3	70.4
Average	June - Sept.	75.3	76.0	76.6	82.7

Source: (U.S. Bureau of Reclamation 2023-2024)

We also assessed the potential adverse impacts to CCV steelhead eggs in the month of June caused by increased water temperatures. Using a temperature threshold of 54°F (Appendix N - Stanislaus SRP in U.S. Bureau of Reclamation 2023-2024), above which temperatures would be expected to be lethal eggs, we identified the percent of months above the threshold by water year type (San Joaquin Valley Index) and month, and for all years combined in the Stanislaus River at Orange Blossom Bridge. Based on Reclamation modeling, the risk of temperatures exceeding in the month of June is 100 percent for the proposed action.

We assessed the months of summer seasonal operations (June–September), and the potential risk associated with elevated temperatures in the Stanislaus River affecting juvenile CCV steelhead

through a number of different mechanisms that may limit growth (66.2°F upper optimal limit of growth without food limitation) and affect susceptibility to disease (59.9°F pathogen virulence threshold). Based on Reclamation's modeling, a summary of the risk of temperatures above the optimal growth threshold and in the summer months of seasonal operations (June–September) is, on average, 2 percent for the proposed action at Orange Blossom Bridge. The level of risk associated with the effects of the proposed action is considered to be low (infrequent, occurring in less than 25 percent of years) regarding the likelihood of temperatures exceeding the 66.2°F upper optimal limit of growth without food limitation. Relative to the NAA, the percentage of time this temperature threshold is exceeded decreases by half a percent to 1.5 percent. Relative to EXP3, there is a significant (33 percent) decrease in temperatures exceeding this threshold.

Reclamation provided information on the percent of months above the 59.9°F pathogen virulence water temperature threshold for juvenile CCV steelhead rearing and out-migration by water year type (San Joaquin Valley Index) and month, and for all years combined, at Orange Blossom Bridge (see Table 83). This modeling showed that the average risk of exceeding the 59.9°F pathogen virulence water temperature threshold at Orange Blossom Bridge during summer seasonal operations (June–September) is about 75.25 percent of months for the proposed action, which is considered a high frequency of exposure (very frequent; occurring in more than 75 percent of years). Relative to the NAA, the proposed action decreases the likelihood of exceeding this temperature threshold by about 1.5 percent, while relative to EXP3, the proposed action decreases the likelihood of exceeding the threshold by about 8 percent of months.

Orange Blossom Bridge is the expected downstream extent of salmonids during the warmer summer months and represents the location of the most severe effects. Water temperatures are progressively cooler in reaches upstream of Orange Blossom Bridge to Goodwin Dam and most of the *O. mykiss* in the Stanislaus River will experience conditions cooler than those at Orange Blossom Bridge. For example, Table 84 (excerpted from Table F.2.11-18-7b, Appendix F in U.S. Bureau of Reclamation 2023-2024 and representing the Alt2v2 implementation of the first 2 years of the proposed action) shows that modeled monthly water temperatures just below Goodwin Dam average less than or equal to 56°F over the summer, even in critical years.

Table 84. Stanislaus River below Goodwin Dam, Alt2v2, Monthly Temperature (°F).

Statistic	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
10% Exceedance	56	55	53	51	51	53	53	54	55	56	56	56
20% Exceedance	55	55	53	51	51	52	52	53	54	55	55	56
30% Exceedance	55	54	52	50	50	51	52	53	54	54	55	55
40% Exceedance	54.3	53.7	51.7	49.6	49.6	51.2	51.8	52.7	53.5	54.0	54.4	54.6
50% Exceedance	53.7	53.2	51.4	49.2	49.4	50.7	51.4	52.3	53.0	53.5	53.9	54.1
60% Exceedance	53.5	52.9	51.0	49.0	49.1	50.4	51.1	52.0	52.5	53.2	53.5	53.9
70% Exceedance	52.9	52.6	50.7	48.7	48.6	50.0	50.7	51.6	52.0	52.7	53.3	53.2

Statistic	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
80% Exceedance	52.6	52.1	50.2	48.3	48.2	49.7	50.4	51.3	51.5	52.4	52.9	52.9
90% Exceedance	52.1	51.8	49.9	47.7	47.7	49.2	49.8	50.8	51.0	51.8	52.4	52.5
Full Simulation Period Average	54	54	52	49	50	51	51	52	53	54	54	54
Wet Water Years (22%)	53	52	51	49	49	50	50	51	51	52	53	53
Above Normal Years (12%)	53	53	51	49	49	50	51	52	52	53	53	54
Below Normal Years (15%)	53	53	51	49	49	50	51	52	52	53	53	54
Dry Years (17%)	54	54	52	50	50	51	52	53	53	54	54	55
Critical (34%)	56	55	53	50	50	52	53	54	54	55	56	56

Source: (Table F.2.11-18-7b in U.S. Bureau of Reclamation 2023-2024)

Water temperature will also interact with the dissolved oxygen stressor where at a 68°F threshold, decreased swimming performance and reduced fitness is observed at dissolved oxygen concentrations less than 9 mg/L. Figure 104 shows the observed dissolved oxygen concentration at Ripon (RPN) over the last 15 years, which during the summer months of June–September is almost entirely below a concentration of 9 mg/L. The risk of adverse effects caused by the interaction of dissolved oxygen and temperature during the same period (June–September) is the proportion of months where temperatures exceed 68°F. Based on Reclamation's modeling of the proposed action, less than 1 percent of months (June–September) are likely to exceed a temperature threshold of 68°F. There is no difference in the likelihood of exceedance relative to the NAA, but a 19 percent decrease relative to EXP3.

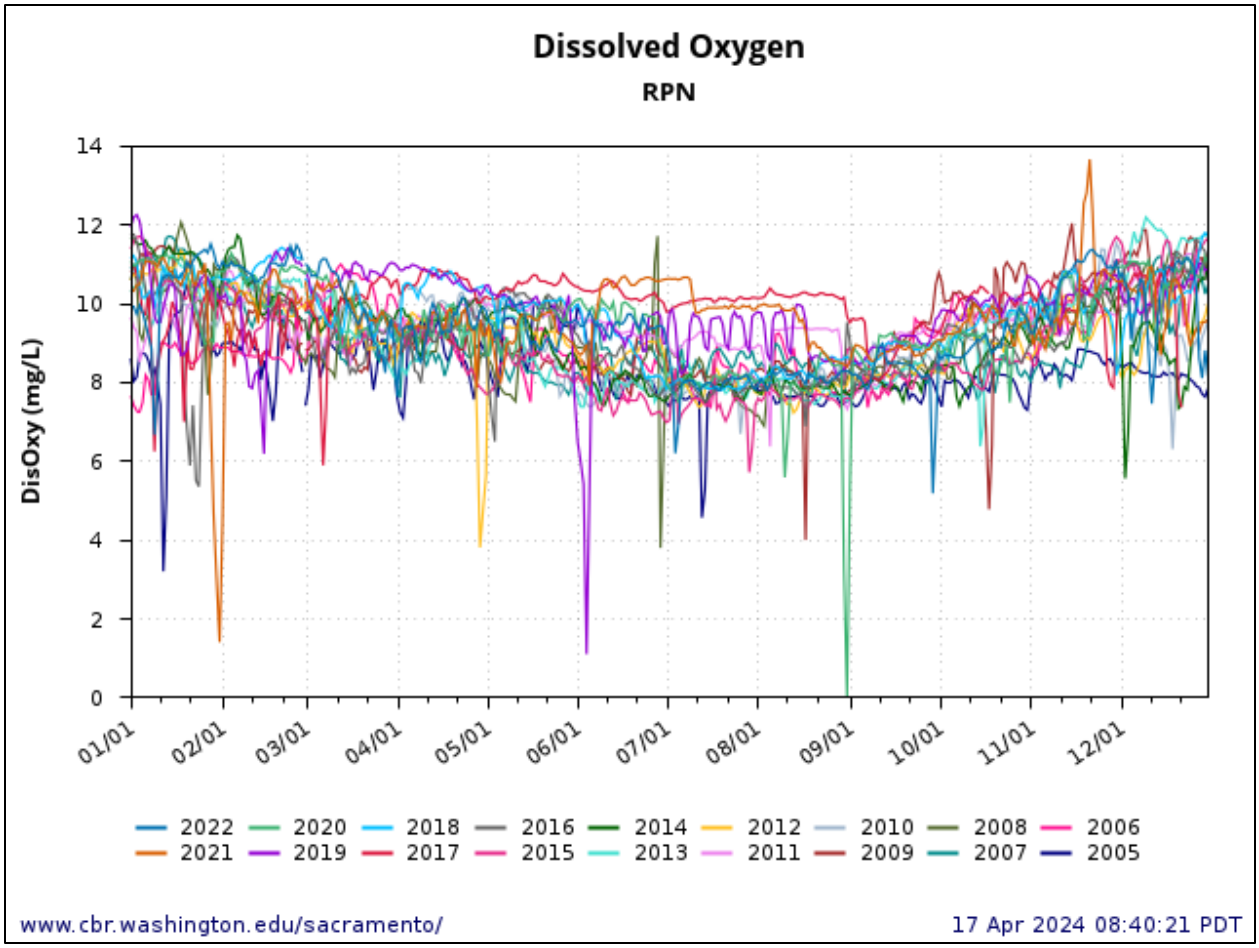


Figure 104. Stanislaus River at Ripon (RPN) daily average dissolved oxygen (mg/L) for years 2005–2022.

Source: SacPAS (University of Washington Columbia Basin Research 2024b)

Table 85 summarizes the effect of water temperature caused by the summer seasonal operations element of the proposed action on CCV steelhead in the Stanislaus River.

Table 85. Information used to identify effects of the water temperature to listed species as a result of East Side Division summer seasonal operations in the Stanislaus River.

Stressor	Life Stage (Location)	Life Stage Timing (Work Window Intersection)	Individual Response and Rationale of Effect	Severity of Stressor	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence
Summer Seasonal Operations (Water Temperature)	Egg incubation	December - June (June)	Reduced egg survival	Lethal	Small	High (annual)	Medium	High
Summer Seasonal Operations (Water Temperature)	Juvenile rearing	Year-round, (June - September)	Decreased growth	Minor	Medium	High (89%)	Medium	Low
Summer Seasonal Operations (Pathogens and Disease)	Adult holding	September - March (October - March)	Increased susceptibility to pathogens and disease	Sublethal	Large	Medium (75%)	Medium	Medium
Summer Seasonal Operations (Pathogens and Disease)	Juvenile rearing	Year-round, (June - September)	Increased susceptibility to pathogens and disease	Sublethal	Medium	Medium (75%)	Medium	Low

Stressor	Life Stage (Location)	Life Stage Timing (Work Window Intersection)	Individual Response and Rationale of Effect	Severity of Stressor	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence
Summer Seasonal Operations (Dissolved Oxygen)	Juvenile rearing	Year-round, (June - September)	Interaction w/ dissolved Oxygen, Reduced smoltification, migration impairment	Minor	Medium	Low (1%)	Low	Low

7.4.1.3.2.2. Flow Condition

During the summer months (June–September) reservoir releases account for most of the flow affecting the flow conditions in the Stanislaus River, a primary driver for a number of potential stressors. The effects of the subsequent stressors follow the effects pathways described in the SAIL conceptual model (Windell et al. 2017), which may be affected by the flow-based management actions of the proposed action. The effects of reduced rearing habitat access and food availability and quantity will result in reduced growth, while reduced dissolved oxygen conditions will result in reduced migration success or reduced survival probability. Here, we measure flow conditions based on the quantity, timing, and quality of water flows relative to those required to sustain fishes and the ecosystems upon which they depend. Because subsequent stressors are influenced by flow conditions, the discussion below focuses on the following specific facets: rearing habitat availability, food availability and quality, and dissolved oxygen.

In the Stanislaus River, dissolved oxygen concerns are typically limited to the summer months where additional releases may be necessary to meet the dissolved oxygen requirement of 7.0 mg/L at the RPN water quality station. Figure 104 shows dissolved oxygen measurements at the RPN gauge from 2005 to 2022, where the lowest, daily average dissolved oxygen measurements tend to occur from June through September. Modeling to support the BA indicates that additional releases of water may be made from Goodwin Dam to meet the downstream dissolved oxygen water quality objective if it cannot be met through the minimum instream flows required by the 2023 SRP. These flows, those identified in the 2023 SRP, and the additional flows that may be necessary to meet the dissolved oxygen requirement are described in Table 86.The proposed action is expected to meet the D-1422 dissolved oxygen standard at RPN, indicating that this particular stressor is adequately managed. Periodically, additional releases, above and beyond the minimum flows described by the SRP, may be made to meet the dissolved oxygen standard, which increases the reliability that the dissolved oxygen stressor would not reach a level that would otherwise negatively affect species of concern.

Table 86. Calculated additional flow (in cubic feet per second) needed (Reclamation modeling) to meet the dissolved oxygen water quality standard at Ripon (RPN) given the water year type prescribed base flow.

Month	Surrogate Flow Release	Critical year flow needed (Surrogate - Base)	Dry year flow needed (Surrogate - Base)	Above Normal/Below Normal years flow needed (Surrogate - Base)	Wet year flow needed (Surrogate - Base)
June	256	106	56	NA	NA
July	265	115	65	15	NA
August	283	133	83	33	NA
September	249	99	49	NA	NA

Exposure

CCV steelhead spawning and egg incubation typically occur between the months of December and June, which only coincides with early summer seasonal operations in the month of June, such that egg or emergent fry exposure would be considered small (exposure less than or equal to 2 percent). However, because of the proposed reservoir ramping rates (see Section 7.4.1.4 Ramping Rates), where flow reductions are implemented slowly enough to monitor for potential dewatering of redds and adaptively managed, the relative risk of dewatering redds in June is considered negligible.

Juvenile CCV steelhead may be found rearing in the upper reaches of the Stanislaus River year-round (National Marine Fisheries Service 2014b, Stanislaus River Scientific Evaluation Process (SEP) Team 2019). A summary of Oakdale rotary screw trap data indicates that about 80 percent of migrating juvenile CCV steelhead are captured in the months of October–May, suggesting that a rearing juvenile CCV steelhead would be present during summer seasonal operations (Eschenroeder et al. 2022). Likewise, surveys of juvenile salmonid rearing in the Stanislaus River (2002–2004 and 2005–2007) show fairly consistent juvenile densities in the lower river year-round, but with the highest juvenile densities (near Goodwin) June through December (Kennedy and Cannon 2005, Kennedy 2008). Given the relatively high species density in the upper river during summer months, as well as the observed core migration that occurs from late fall through spring, it is expected that summer seasonal operations coincide with a medium proportion (more than 2 percent, but less than 70 percent) of the juvenile life stage.

Response

Flow conditions can affect the juvenile life stage in multiple, interconnected ways. Specifically, the proposed release of previously stored water may affect the rearing habitat availability stressor where summer seasonal operations of the proposed action will result in decreased flows in the Stanislaus River below Goodwin Dam that will alter the extent of habitat inundation and juvenile access. The relative availability of habitat will, in turn, affect how much and of what quality food is available to rearing juveniles. Windell et al. (2017) focused on the growth and condition of juveniles as being influenced by the availability of, and access to, riparian habitats that determine food availability and quantity. The change in fitness, measured as growth rate, is dependent on the bioenergetic expenditure to obtain a given food supply.

Table 80 and Table 81 show the total rearing WUA and ASH, respectively, for the proposed action, NAA and EXP3 modeling scenarios. The WUA values of the proposed action range from 1,211,607 to 1,272,542, while the ASH values of the proposed action range from 662,022 to 808,569 square feet. Both the WUA and ASH results fail to discern much in the way of a difference between the proposed action and the NAA, meaning that rearing habitat quantity and/or quality would be the same for the proposed action and the NAA. Generally, the WUA analysis describes an average 22 percent increase in access to quality rearing habitats and food availability for the proposed action relative to the EXP3 modeling scenario. The ASH analysis shows similar but less pronounced results, with a relative 9 percent increase in suitable rearing habitat for the proposed action.

Because the habitat conditions characterized by the WUA and ASH results of the proposed action would occur annually, the likelihood (risk) associated with these increases in habitat and food availability is expected to occur annually. However, given the opportunity cost of habitat use (i.e., an individual can only rear in a single location at any given time), the relative increase or decrease in habitat availability serves as a surrogate for the likelihood of using that habitat. The analysis of CCV steelhead rearing habitat describes a 22-percent increase in rearing habitat WUA for the proposed action (Alt2v1) relative to the EXP3 modeling scenario. The ASH analysis showed a similar but less pronounced (9 percent) increase in area of suitable habitat for CCV steelhead rearing under the proposed action relative to EXP3 modeling.

The potential adverse impact associated with potential low dissolved oxygen conditions occurring under the proposed action is small for a number of reasons. The dissolved oxygen standard at RPN is consistently met on an annual basis with only critical and dry water year types sometimes needing additional reservoir releases above the base flows described in the 2023 SRP for the months of June and September. Although 10 out of the last 18 years (2005–2022) have been classified as critical or dry water year types, dissolved oxygen at RPN has not dropped below the D-1422 standard (7 mg/L) with only a few exceptions. Furthermore, the D-1422 standard is more protective than the dissolved oxygen level (5 mg/L) at which we expect to begin to observe behavioral changes in salmonids (Hallock et al. 1970). Given the frequency with which the standard is met under the proposed action and the protective quality of the dissolved oxygen standard itself, the relative risk posed by low dissolved oxygen conditions in the Stanislaus River is considered low.

Table 87 summarizes the effects of flow caused by the summer seasonal operations element of the proposed action on CCV steelhead in the Stanislaus River.

Table 87. Information used to identify effects of flow condition on California Central Valley steelhead as a result of East Side Division summer seasonal operations element of the proposed action in the Stanislaus River.

Stressor	Life Stage (Location)	Life Stage Timing (Work Window Intersection)	Individual Response and Rationale of Effect	Severity of Stressor	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence
Summer Seasonal Operations (Rearing Habitat)	Juvenile rearing	Year-round, (June - September)	Increased rearing habitat availability	Low	Medium	Low (+9% to 22%)	Low	Medium
Summer Seasonal Operations (Food Availability and Quality)	Juvenile rearing	Year-round, (June - September)	Increased food availability and/or quality	Low	Medium	Low (+9% to 22%)	Low	Medium
Summer Seasonal Operations (Dissolved Oxygen)	Juvenile rearing	Year-round, (June - September)	Reduced swimming performance and preference/avoidance behavior	Minor	Medium	Low	Low	Medium

7.4.1.4. Ramping Rates

As part of the proposed action, Reclamation has identified ramping rates for releases made from Goodwin Dam to address the potential stranding risk stressor associated with seasonal operations. Specifically, Reclamation will coordinate releases on the Stanislaus River as shown in Table 88. The determination of the water year type will be made using the San Joaquin Valley "60-20-20" Water Year Hydrologic Classification and based on a 90-percent exceedance forecast.

Table 88.Goodwin Dam ramping rates.

Goodwin Release Range (cfs)	Standard Rate of Increase (cfs per 2 hours)	Standard Rate of Decrease (cfs per 2 hours)	Critical and Dry Water Year Type Rate of Increase (cfs per 2 hours)	Critical and Dry Water Year Type Rate of Decrease (cfs per 2 hours)
At or above 4,500	250	250	250	250
2,000 to 4,499	500	250	500	250
500 to 1,999	250	100	500	200
300 to 499	100	50	200	100

cfs = cubic feet per second.

Source: (U.S. Bureau of Reclamation 2023-2024)

Exceptions to the ramping rates identified in Table 88 may be considered by the SWT and implemented by Reclamation on a case-by-case basis. For the shaping of winter instability flows by the SWT, Reclamation may implement faster ramping rates in critical and dry water year types if doing so would improve biological benefits. Likewise, during periods of flood control Reclamation may increase the rate of releases at Goodwin beyond the ramping requirements identified in Table 88. As a general approach, however, Reclamation considers ramping rates that promote recruitment of native riparian vegetation on floodplain surfaces when instream flow budgets are sufficient to do so. The Ramping Rates proposed element for the East Side Division proposed action is understood to affect the environmental drivers and conditions related to the hydrology of the river. Specifically, the stressor associated with this environmental attribute is:

- **Flow Conditions**, which affects the Stranding and Dewatering stressor.

Table 89 summarizes the effects of flow caused by the ramping rate element of the proposed action on CCV steelhead in the Stanislaus River.

Table 89. Previously identified effects of flow conditions on California Central Valley steelhead as a result of the proposed action ramping rates in the Stanislaus River.

Stressor	Life Stage (Location)	Life Stage Timing (Work Window Intersection)	Individual Response and Rationale of Effect	Severity of Stressor	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence
Ramping Rates (Fall, Winter, Spring Seasonal Operations)	Egg incubation	December - June (December - June)	Increased egg survival (Mitigating Seasonal Operations)	High	Large	Low	High	Low
Ramping Rates (Fall, Winter, Spring Seasonal Operations)	Juvenile rearing	Year-round, (October - May)	Increased juvenile survival (Mitigating Seasonal Operations)	High	Large	Low	High	Low

In general, the proposed ramping rates of the proposed action have a mitigating effect on other proposed action components (e.g., Fall, Winter, and Spring Seasonal Operations), where the risk associated with those effects is reduced. Specifically, Section 7.4.1.3.1 Fall/Winter/Spring describes the risk associated with flow conditions during the fall, winter, and spring seasonal operations that can result in eggs/redds being dewatered and juveniles being stranded. Both dewatering and stranding will result in a probable change in fitness of reduced survival of the individual.

7.4.1.5. Minimum Instream Flows

Minimum instream flows are proposed according to the 2023 New Melones SRP (U.S. Bureau of Reclamation 2023-2024), which includes the ability to shape monthly and seasonal flow volumes to meet biological objectives depending on year type. The determination of the water year type will be made using the San Joaquin Valley "60-20-20" Water Year Hydrologic Classification and based on a 90-percent exceedance forecast. The effect of the SRP minimum instream flows are reflected in the assessment of seasonal operations, where the ability to shape seasonal flow volumes provides a means to improve environmental conditions and minimize potential stressors. This element of the East Side Division proposed action is understood to affect the environmental drivers and conditions related to the hydrology of the river.

7.4.1.5.1. Fall Pulse Flows

The fall pulse flow action is intended to improve instream conditions and provide an attraction cue for adult salmonids, providing access to spawning habitat. Reclamation will release an additional flow volume in October and/or November that is coordinated and scheduled through the SWT such that the volumes are consistent with those specified in the SRP and considering other system objectives. Specifically, the environmental attribute affected by the proposed action and the subsequent stressor associated with it is:

- **Flow Conditions**, which affects adult Spawning Habitat Availability.

7.4.1.5.2. Winter Instability Flows

Winter instability flows address the out-migration cues and juvenile rearing habitat stressors. Reclamation releases additional flow in February, as provided in the 2023 SRP, to simulate natural variability in the winter hydrograph and to enhance access to rearing habitats. Reclamation, through the SWT, schedules the winter instability flow volume. Whenever possible the pulse is scheduled to coincide with a natural storm event, which may provide natural cues for migration. In some years, natural rain events may provide sufficient natural variability in the hydrograph such that an additional pulse may be unnecessary. In those years, Reclamation, through the SWT, will prepare an assessment of rain events to determine whether the natural flow is sufficient to meet the intent of the winter instability flows. This period (February) corresponds to the period of about 10 percent of juvenile CCV steelhead migration (Eschenroeder et al. 2022). The environmental attribute affected by the proposed action and the subsequent stressor associated with it is:

- **Flow Conditions**, which affects Juvenile Migration Cues and Rearing Habitat Availability.

7.4.1.5.3. Spring Pulse Flows

Spring pulse flows are intended to ameliorate the negative impacts to the environmental conditions providing out-migration cues and access to juvenile rearing habitat. Starting as early as March, Reclamation will release additional flows through late June to improve habitat conditions and provide hydrologic cues to encourage juvenile migration. This period (March–June) corresponds to the period of greatest migration for juvenile steelhead where about 69 percent of juveniles are moving to the lower river (Eschenroeder et al. 2022). Reclamation, through the SWT, will schedule spring pulse flow volumes consistent with volumes in the 2023 SRP. Specifically, the environmental attribute affected by the proposed action and the subsequent stressor associated with it is:

- **Flow Conditions**, which affect Juvenile Migration Cues and Rearing Habitat Availability.

Table 90 summarizes the effects of flow caused by the minimum instream flow element of the proposed action on CCV steelhead in the Stanislaus River.

Table 90. Previously identified effects of flow conditions on California Central Valley steelhead minimized as a result of minimum instream flows in the Stanislaus River.

Stressor	Life Stage (Location)	Life Stage Timing (Work Window Intersection)	Individual Response and Rationale of Effect	Severity of Stressor	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence
Minimum Instream Flows (Fall Pulse Flows)	Adult migration	September - March (October / November)	Increased spawning habitat access (Mitigating Seasonal Operations)	Low	Small	High	Low	Medium
Minimum Instream Flows (Winter Instability Flows)	Juvenile migration	Primarily February – May (February)	Increased migration survival (Mitigating Seasonal Operations)	Medium	Small	High	Low	Medium
Minimum Instream Flows (Winter Instability Flows)	Juvenile rearing	Year-round, (February)	Increased rearing habitat availability (Mitigating Seasonal Operations)	Low	Small	High	Low	High
Minimum Instream Flows Spring Pulse Flows)	Juvenile migration	Primarily February – May (March - June)	Increased migration survival (Mitigating Seasonal Operations)	Medium	Medium	Low	Low	Medium

Stressor	Life Stage (Location)	Life Stage Timing (Work Window Intersection)	Individual Response and Rationale of Effect	Severity of Stressor	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence
Minimum Instream Flows (Spring Pulse Flows)	Juvenile rearing	Year-round, (March - May)	Increased rearing habitat availability (Mitigating Seasonal Operations)	Low	Medium	Low	Low	High

7.4.1.6. Summary of Effects to California Central Valley Steelhead

Table 91 describes the life stages, primary stressors and effect pathways, and relevant management actions for each operational season on the Stanislaus River for CCV steelhead. The purpose of Table 91 is to succinctly summarize the primary consequences of the proposed action without comparison to other scenarios or conditions. These effects that are summarized in Table 91 also will be carried forward to the Integration and Synthesis section of the opinion.

Table 91. California Central Valley steelhead summary of primary affected life stages, primary stressors/effect pathways, and relevant management actions for seasonal operations periods of the proposed action. These are the elements that will be incorporated into the Integration and Synthesis section of the opinion.

Division/ Waterbody	Seasonal Operations Period	Affected Life Stage	Summary of Primary Stressors and Effects of the Proposed Action	Relevant Management Actions
Stanislaus and East Side Division	Fall, winter, and spring operations	Adults	Water temperature ● Exceed thresholds for impairing adult migration in ~3% of months and 25% of years ● Exceed thresholds for impairing gamete viability in 10.5% of months ● 59.9°F threshold for increased virulence exceeded in 1% of months in 25% of all years	Minimum instream flows, Stanislaus Watershed Team
		Egg incubation	Water temperature ● 54°F mortality threshold exceeded in an average of 49% of months with a low of 6% of all Januarys and a high of 94% of all Mays	
		Juveniles	Water temperature ● Exceed optimal levels for growth and survival in 2.3% of months ● Exceed levels that impair smoltification an average of 27% of years ● 59.9°F threshold for increased virulence exceeded in 1% of months in 25% of all years	Minimum instream flows, Stanislaus Watershed Team

Division/ Waterbody	Seasonal Operations Period	Affected Life Stage	Summary of Primary Stressors and Effects of the Proposed Action	Relevant Management Actions
		Juvenile rearing	Flow conditions ● Spring pulse flows and winter instability flows improve juvenile out-migration cues and adult upstream migration cues ● Weighted Usable Area averages is 1,246,593, low in critical years of 1,211,607, high in wet years of 1,272,542 ● Suitable rearing habitat averages 718,884, low in critical years of 662,022, high in wet years of 808,569	Minimum instream flows, Winter Instability Flows, Spring Pulse Flows, Stanislaus Watershed Team
	Summer	Juvenile rearing	Water temperature ● Exceeds thresholds for increased virulence an average of 75.3 of months, a low of 54.1% of all Junes, and a high of 96.9% of all Julys. ● Exceeds temperatures of optimal growth conditions in 89% of months ● Exceeds temperatures that trigger low dissolved oxygen concentrations in less than 1% of years	Minimum instream flows, Stanislaus Watershed Team

7.4.1.7. Central Valley Spring-Run Chinook Salmon Exposure and Response

Although the Stanislaus River is not designated critical habitat for CV spring-run Chinook salmon, it does provide habitat for adult and juvenile migration, egg incubation, spawning, and rearing life stages. New data and information suggest passive reestablishment of CV spring-run Chinook salmon in the San Joaquin River and tributaries: Stanislaus, Mokelumne, and Tuolumne rivers (Franks 2014, Johnson 2016, Gutierrez et al. 2024). In addition, a genetics report by Clemento and Garza (2023) concluded that spring-run Chinook salmon ancestry was identified in the San Joaquin River tributaries, including the Stanislaus River. Rotary screw trap data collected by Pacific States Marine Fisheries Commission, on the behalf of the USFWS Comprehensive Assessment and Monitoring Program and CDFW[18], show that over the last 7 years (2017–2023), only one juvenile Chinook salmon, classified as spring-run based on length at date, was genetically confirmed to be a CV spring-run Chinook salmon (Hickey and Bradbury 2018). It is conceivable, however, that adult CV spring-run Chinook salmon returns to the San

[18] Stanislaus River at Caswell Memorial State Park - Rotary Screw Trap Monitoring Annual Reports; available at: https://www.calfish.org/ProgramsData/ConservationandManagement/CentralValleyMonitoring/StanislausRiver-RSTMonitoring.aspx

Joaquin River tributaries represent the early stages of reestablishing a population and a process trending towards a self-sustaining population (Johnson et al. 2023a, Gutierrez et al. 2024).

Based on CV spring-run Chinook salmon adult migration timing in the San Joaquin River (Sutphin et al. 2019, Sutphin and Root 2021, 2022), egg incubation to fry emergence are assumed to occur from September through January, with juvenile rearing from November through May for juveniles that emigrate as young-of-year and year-round for juveniles that emigrate as yearlings. NMFS expects that any CV spring-run Chinook salmon in the Stanislaus River would experience similar exposure as CCV steelhead, with the addition of over-summering adults being exposed to lethal summer water temperatures. Based on observations and seasonal timing, most juvenile CV spring-run Chinook salmon out-migrate from the Stanislaus River during periods when dissolved oxygen levels are suitable, and NMFS expects an exposure and response similar to that experienced by CCV steelhead. Central Valley spring-run Chinook salmon access to habitat and food/prey abundance is likewise expected to have a pattern of exposure and response that is similar to CCV steelhead with a low beneficial effect of increased spawning success and increased juvenile growth relative to conditions described by the obligated release scenario.

While there have been observations of CV spring-run Chinook salmon in the Stanislaus River in the last decade and recently (Franks 2014, Gutierrez et al. 2024), we lack sufficient information to determine whether these fish constitute a population that should be part of the listed CV spring-run Chinook salmon ESU, as direct monitoring for CV spring-run Chinook salmon does not exist in the lower San Joaquin River basin currently. Therefore, NMFS does not further consider the effects of the proposed action on these fish within the Stanislaus River in the jeopardy analysis for this species. Furthermore, as it pertains to the potential effects of the action on the distribution of the ESU, NMFS finds the proposed action would not reduce that distribution, and therefore the Stanislaus River remains a candidate area for reintroduction of CV spring-run Chinook salmon consistent with the NMFS recovery plan (National Marine Fisheries Service 2014b).

Table 92 describes the life stages, primary stressors and effect pathways, and relevant management actions for each operational season on the Stanislaus River for CV spring-run Chinook salmon. The purpose of

Table 92 is to succinctly summarize the primary consequences of the proposed action without comparison to other scenarios or conditions. These effects that are summarized in

Table 92 also will be carried forward to the Integration and Synthesis section of the opinion.

Table 92. Central Valley spring-run Chinook salmon summary of primary affected life stages, primary stressors/effect pathways, and relevant management actions for seasonal operations periods of the proposed action. These are the elements that will be incorporated into the Integration and Synthesis section of the opinion.

Division/Water body	Seasonal Operations Period	Affected Life Stage	Summary of Primary Stressors and Effects of the Proposed Action	Relevant Management Actions
Stanislaus River	All Seasons	All freshwater life stages	Effects to Central Valley spring-run Chinook salmon are similar as those described for California Central Valley steelhead. Including elevated water temperatures that exceed holding, spawning and rearing requirements; water temperatures that trigger virulence; and beneficial impacts of pulse flows.	Seasonal temperature objectives, pulse flows, and minimum instream flows

7.4.2. Effects of the Action on Critical Habitat in the Stanislaus River

The only designated critical habitat for ESA-listed salmonids in the Stanislaus River is for CCV steelhead, which has been designated up to Goodwin Dam. The physical or biological features of critical habitat in the Stanislaus River include freshwater spawning sites, freshwater rearing sites, and freshwater migration corridors.

7.4.2.1. Effects to Salmonid Spawning Habitat Physical and Biological Features

California Central Valley steelhead spawning habitat PBFs on the Stanislaus River is affected by East Side Division operations in two key categories:

- **Water Temperature,** as flow releases may not maintain appropriate temperatures for spawning and egg incubation, particularly in March, April, May, and June
- **Flow Condition,** where releases do not support geomorphic processes that would remove fine sediment from spawning gravels and maintain interstitial flows, attract spawners, and allow egg incubation

For the proposed action, the modeled, monthly average water temperatures at Orange Blossom Bridge exceed the SRP-established (Appendix N - Stanislaus SRP in U.S. Bureau of Reclamation 2023-2024) criterion for CCV steelhead egg incubation (54°F) in all months of the egg incubation period (December–June). Table 93 shows the percentage of those months, averaged across all water year types, that exceed 54°F. Table 93 also shows that the preponderance of March, April, May, and June months do not provide suitable temperatures for CCV steelhead egg incubation. The impacts of the proposed action are expected to limit the

access and availability of fresh water spawning and rearing habitats. Relative to the NAA, the proposed action will change the likelihood of exceeding 54°F by about 5 percent depending on the month. Likewise, relative to EXP3, the proposed action increases the frequency of temperatures exceeding 54°F during the egg incubation months of December and March by 3 to 8 percent, and decreases the frequency by 1 to 3 percent in January, February, April, and May.

Table 93. Percentage of months (December–July) above the 54°F criterion for egg incubation averaged across all water year types in the Stanislaus River at Orange Blossom Bridge for each modeling scenario.

Water Year Type	Month	Proposed Action Alt2v2	Proposed Action Alt2v1	NAA	EXP3
All	Dec.	26.5	26.5	24.5	22.4
All	Jan.	6.1	6.1	6.1	7.1
All	Feb.	20.4	20.4	24.5	24.5
All	March	74.5	73.5	71.4	65.3
All	April	72.4	72.4	67.3	73.5
All	May	93.9	93.9	95.9	96.9
All	June	100	100	100	100
All	July	100	100	100	100

Source: (U.S. Bureau of Reclamation 2023-2024)

Figure 103 shows the average monthly flows in the Stanislaus River below Goodwin Dam for all water year types. For comparison, Figure 105 shows the natural, unregulated monthly inflow to New Melones Dam with inflows peaking in the months of April and May. Historically, those flows in the months of December through June would have provided for geomorphic processes that remove fine sediment from spawning gravels and maintain interstitial flows within redds and around incubating eggs. Under the proposed action, inflow from the upper watershed is captured by reservoir operations so that average flows below New Melones in December, January and February will be 527 cfs, 799 cfs, and 1,045 cfs respectively. Relative to the NAA, proposed action flows in those months increase or decrease by up to 7 percent. Relative to EXP3, proposed action flows in those months are reduced by about 25 to 33 percent. Ultimately the proposed action modeling shows that flows will be diminished in this reach of the Stanislaus River, and given that these flows are provided in an already-degraded habitat, they are likely to further constrain the ability of that habitat to function in a way that supports species needs.

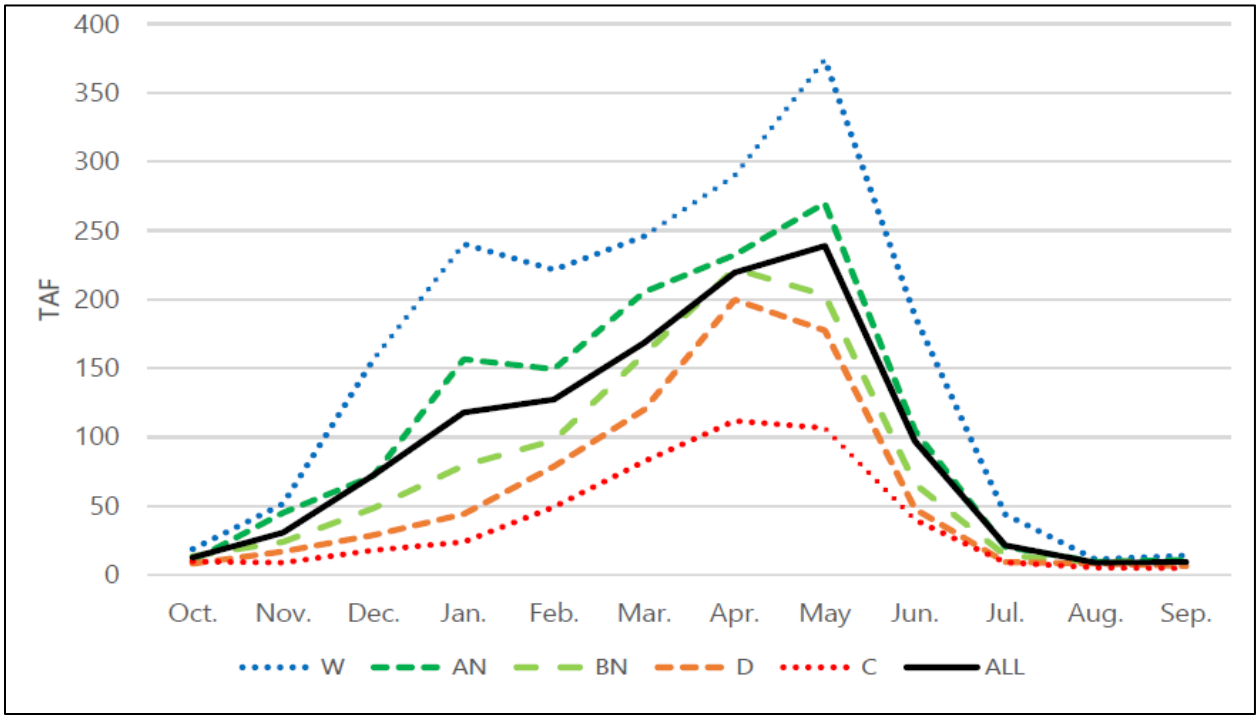


Figure 105. Inflow from the natural, unregulated sources to New Melones Reservoir by month and water year type.

Source: (U.S. Bureau of Reclamation 2023-2024)

7.4.2.1.1. Freshwater Rearing Habitat for Juveniles

The freshwater rearing sites PBF includes water quantity and floodplain connectivity to support juvenile growth and mobility, and water quality and forage to support juvenile development. The monthly availability and access to the freshwater rearing PBF is described in Figure 106, where instream rearing habitat availability is relatively stable across months. The proposed action shows that acres of rearing habitat in the Stanislaus River throughout the year range from 7.4 to 8.25 acres, depending on the month. There is little difference in rearing habitat availability between the proposed action, NAA and EXP3 modeling scenarios.

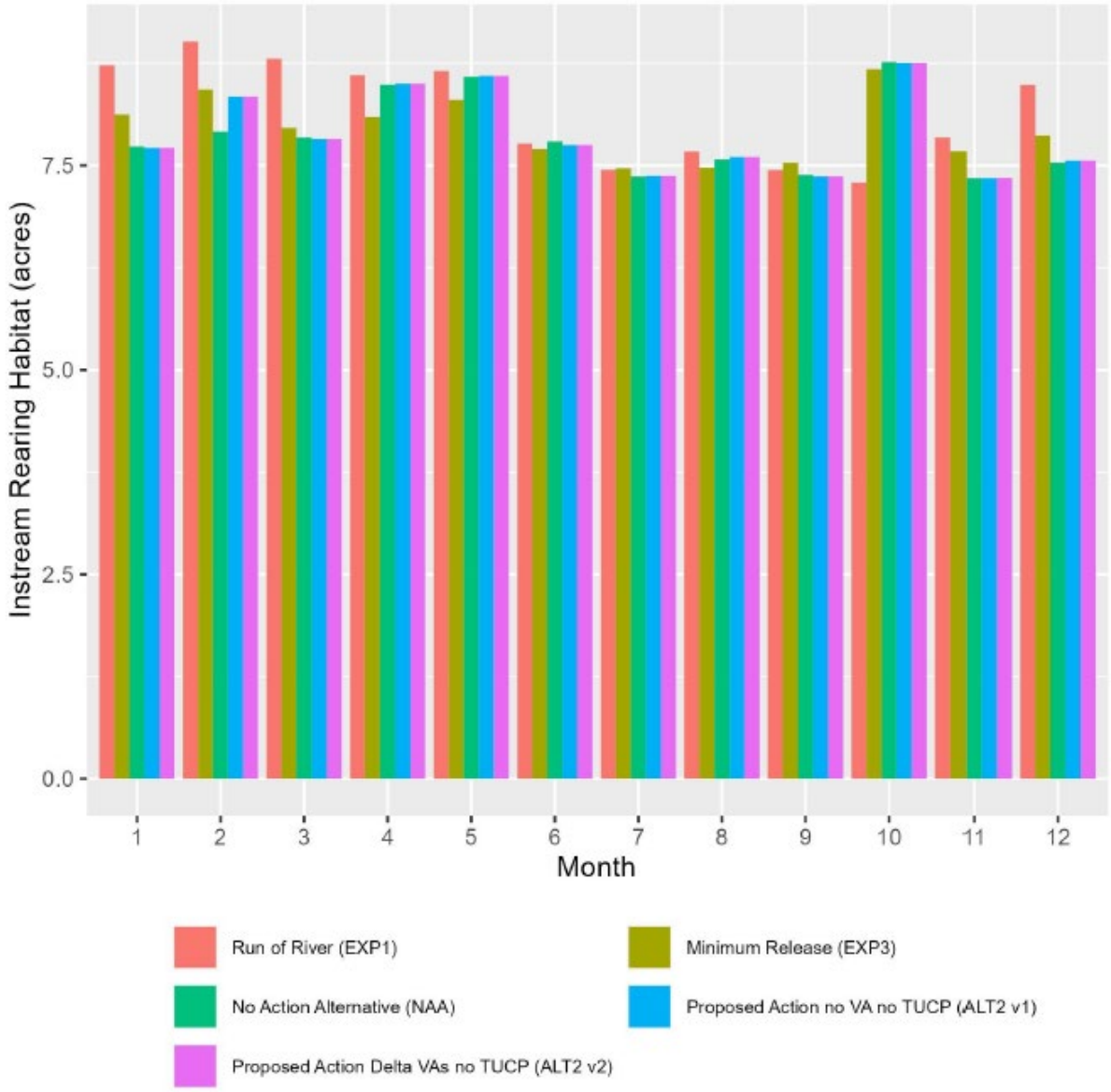


Figure 106. Estimated instream rearing habitat for juvenile California Central Valley steelhead in the Stanislaus River.

Source: (U.S. Bureau of Reclamation 2023-2024)

Similarly, Figure 107 shows floodplain rearing habitat availability for the different modeling scenarios, which shows acres of floodplain rearing habitat under the proposed action throughout the year range from almost no access to just over 80 acres of habitat, depending on the month. Relative to the NAA, the proposed action provides a very similar level of floodplain rearing habitat access, differing by only a very small fraction of an acre depending on the month. Relative to EXP3, the proposed action shows medium to large reductions in floodplain rearing habitat availability.

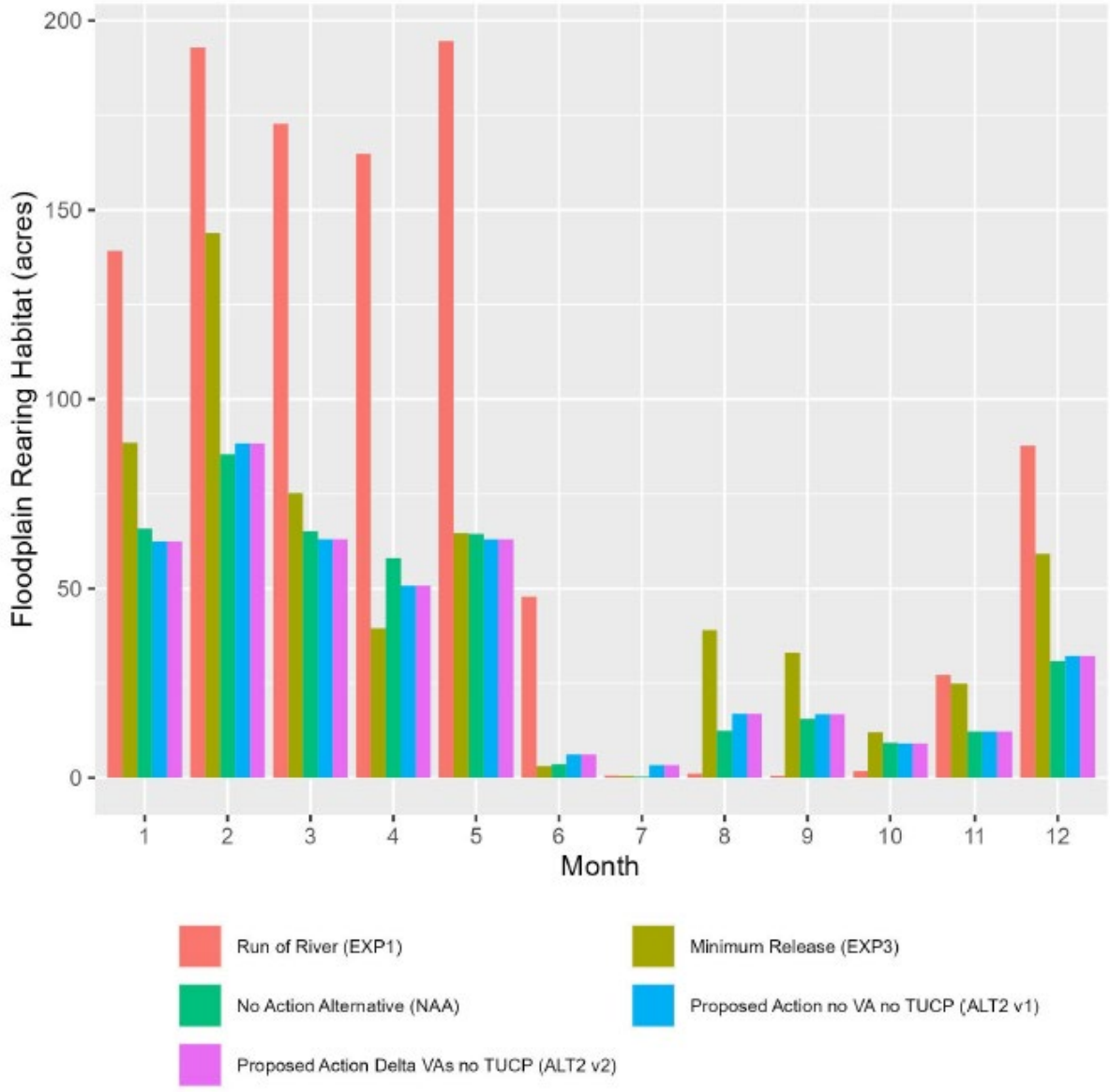


Figure 107. Estimated floodplain rearing habitat for juvenile California Central Valley steelhead in the Stanislaus River.

Source: (U.S. Bureau of Reclamation 2023-2024)

7.4.2.1.2. Freshwater Migratory Corridors for Out-Migrating Juveniles and Migrating Adults

The freshwater migratory corridors PBFs are primarily a representation of habitat connectivity and whether there are any barriers to migration, physical or otherwise (e.g., temperature). Under proposed action operations, the freshwater migration corridors on the Stanislaus River will continue to require adult and juvenile CCV steelhead to pass water temperatures that may impair migration or be lethal (see Section 7.4.1.3 Seasonal Operations).

During the months of October–March (adult migration), water temperatures provided by the proposed action in the Stanislaus River at the confluence with the San Joaquin River may reach temperatures understood to impair the migration of adults (EPA 2003). Specifically, temperatures have been modeled higher than the 66.2°F upper limit of adult migration impairment, in about 1 percent of Octobers under proposed action operations (see Section 7.4.1.3.1.1 Water Temperatures for details). Likewise, temperatures in the Stanislaus River near the confluence with the San Joaquin River during the primary period of CCV juvenile steelhead migration (February–May) are modeled to exceed 55°F in a large proportion of months (see Table 94).

Table 94. Percent of months above the 55°F migration impairment water temperature limit for California Central Valley steelhead by water year type (San Joaquin Valley Index) and month and for all years combined, in the Stanislaus River above the confluence with San Joaquin River, from February through May.

Water Year Type	Month	Proposed Action Alt2v2	Proposed Action Alt2v1	NAA	EXP3
All	Feb.	11.2	11.2	17.3	18.4
All	March	75.5	74.5	73.5	67.3
All	April	89.8	89.8	90.8	92.9
All	May	99	99	99	98

7.4.2.1.3. Summary of Effects to Critical Habitat in the Stanislaus River

Table 95 summarizes the effects of the proposed action on CCV steelhead designated critical habitat in the Stanislaus River.

Table 95. Information used to identify the effects of the proposed action to critical habitat in the Stanislaus River.

Action Component	Location of Effect	Physical and Biological Features Affected	Response and Rationale of Effect	Magnitude of Effect	Weight of Evidence
Seasonal Operations	Downstream of Goodwin Dam to Orange Blossom Bridge	Spawning Habitat	Temperatures not suitable for egg incubation, and diminished flows in and around redds	Lethal	Medium
Seasonal Operations	Downstream of Goodwin Dam to Ripon (RPN)	Rearing Habitat	Reduced acreage of rearing habitats	Minor	Medium
Seasonal Operations	Downstream of Goodwin Dam to the confluence	Freshwater Migratory Corridors	Persistent barriers to juvenile migration	Minor	Medium

7.4.3. Effects of the Action on Species in the San Joaquin River

The BA notes "Reclamation would operate the Friant Division consistent with the San Joaquin River Restoration Program Record of Decision, which is a related action not included in this consultation. While no proposed action element of CVP and SWP operations is initiated in this region, the San Joaquin River between the confluence with the Stanislaus River and Mossdale is part of the action area analyzed in this biological opinion, so conditions are evaluated here. The seasonal conditions addressed in this effects analysis fall into the categories of water quality objective management and flow management. These categories of management are understood to affect the environmental attributes of dissolved oxygen, food availability and quality, water temperature, pathogens and disease, habitat availability, and juvenile migration cues (Windell et al. 2017). This analysis focuses on the conditions in the San Joaquin River downstream of the confluence with the Stanislaus River.

Table 96 provides a summary of those stressors affected by the proposed action and analyzed for the East Side Division, which have been adapted for CCV steelhead and CV spring-run Chinook salmon based on the SAIL conceptual model (Windell et al. 2017). The exposure, response, and risk of CCV steelhead and CV spring-run Chinook salmon to the project-related stressors are then analyzed in the following sections for the proposed action. Likewise, effects to sDPS green sturgeon are reviewed, as their presence is documented in the San Joaquin River as reported in Sturgeon Fishing Report Cards.[19]

Table 96. Stressors/attributes in the mainstem San Joaquin River affected by components of the proposed action.

	Water Temperature	Dissolved Oxygen	Juvenile Migration Cues	Pathogens and Disease	Food Availability and Quality	Habitat Availability
Seasonal Conditions (Stanislaus River Confluence to the Delta)	X	X	X	X	X	X

The analysis in this section, and references to "San Joaquin River," are limited in geographic extent to the San Joaquin River from the confluence with the Stanislaus River, downstream past Vernalis to approximately Mossdale. While a portion of this reach of the San Joaquin River is in the Bay-Delta Division, there are several reasons to consider it separately from the Bay-Delta Division effects section. First, conditions are primarily driven by upstream operations on CVP and non-CVP watersheds (including operations on the Stanislaus River) rather than Delta

[19] Available at the CDFW Bay Delta Region sturgeon data bibliography page here: https://wildlife.ca.gov/Conservation/Delta/Sturgeon-Study/Bibliography

operations. Second, this reach of the San Joaquin River is primarily riverine, while further in the Delta the San Joaquin River is primarily tidal. While this reach of the river does not contain any operational components of the proposed action (Table 76; i.e., there are no diversions or dam operations in this reach), conditions in the reach are affected by (1) San Joaquin River flow from upstream of the confluence with the Stanislaus River, and (2) flow entering the San Joaquin River from the Stanislaus River as a result of East Side Division operations, which are a component of the proposed action (described in detail in the Effects of the Action on Species in the Stanislaus River section). NMFS evaluates the effects of East Side Division operations in this reach of the San Joaquin River, in combination with the required releases, accretions and depletions.

7.4.3.1. Seasonal Conditions

The effects of the East Side Division operations on this reach of the San Joaquin River under the proposed action are provided in this section. See the Effects of the Action on Species in the Stanislaus River section for a detailed discussion of how East Side Division operations on the Stanislaus River affect the conditions in that tributary. The seasonal conditions affected by operations of the East Side Division are understood to affect the environmental drivers and habitat attributes related to the temperature and hydrology of the river. Stressors associated with these environmental attributes at this location include:

- **Water Temperature,** which in turn may influence the pathogens and disease stressor, and interact with the dissolved oxygen stressor
- **Flow Condition,** which affects rearing habitat availability, juvenile migration cues, and food availability and quality

7.4.3.1.1. Water Temperature

Monthly average water temperatures at the confluence of Stanislaus and San Joaquin rivers based on the San Joaquin ("60-20-20") year type are provided in Table 97 to show the range of temperatures expected under the proposed action modeling scenario.

Table 97. Monthly average water temperatures (°F) at the mouth of the Stanislaus River by month and San Joaquin ("60-20-20") year type for proposed action.

Statistic	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
10% Exceedance	63	58	52	53	55	61	64	67	72	76	75	72
20% Exceedance	62	57	52	52	55	60	63	66	71	75	74	71
30% Exceedance	62	56	51	51	54	60	62	65	71	75	74	71
40% Exceedance	61.0	55.9	50.9	50.7	53.1	59.0	61.5	64.1	70.4	74.4	73.6	70.2
50% Exceedance	60.7	55.5	50.5	50.3	52.5	58.3	59.2	62.0	69.0	74.0	73.2	70.0
60% Exceedance	60.2	55.3	50.0	49.8	52.0	57.6	58.5	60.5	68.3	73.4	72.8	69.6

Statistic	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
70% Exceedance	59.6	54.7	49.9	49.3	51.7	56.4	57.1	59.7	67.3	73.0	72.3	68.5
80% Exceedance	59.3	54.3	49.4	49.1	51.3	54.3	55.7	58.9	66.3	72.7	71.9	68.0
90% Exceedance	58.6	53.9	49.1	48.6	50.2	52.5	55.0	57.5	63.1	70.8	67.7	61.3
Full Simulation Period Average	61	56	51	51	53	58	59	62	69	74	72	69
Wet Water Years (22%)	59	55	51	51	51	55	56	58	64	72	69	64
Above Normal Years (12%)	60	55	50	50	51	56	56	60	68	73	73	70
Below Normal Years (15%)	60	55	51	50	52	56	58	61	68	74	73	70
Dry Years (17%)	61	56	51	51	53	59	61	65	71	75	74	70
Critical (34%)	62	56	51	50	54	60	63	66	71	75	73	70

Exposure

Life history timing of CCV steelhead adults and juveniles in the mainstem San Joaquin River is described in the Status of the Species section where adults are expected in the Lower San Joaquin River from September through March. Additionally, CCV steelhead may exit natal river reaches during winter storm flows similar to juvenile Chinook salmon, as described in Sturrock et al. (2015), and rear in the mainstem San Joaquin River from roughly December to May. Some CCV steelhead in the mainstem San Joaquin River may residualize and not exhibit the sea-going life history, but water temperatures in the mainstem San Joaquin River are typically above the suitable temperature range for juvenile CCV steelhead in the summer and fall, so juveniles would not be expected to be present in those seasons.

Response

Expected, temperature-related effects from seasonal conditions under the proposed action in the Lower San Joaquin River will expose CCV steelhead to potential migrational delays due to poor water quality, which may also increase vulnerability to pathogens and disease, affecting survival. Specifically, adult CCV steelhead migrating or holding in temperatures above 62.6°F would result in a minor effect of migration delay and impairment. Temperatures above 57.2°F will also affect the relative susceptibility of adults to disease and pathogens. Juvenile CCV steelhead exposed to temperatures in the range of 53.6°F to 59°F will experience impaired smoltification, while prolonged exposure to temperatures in the range of 73.4°F to 78.8°F is considered lethal

(EPA 2003). Like adults, juvenile susceptibility to pathogens and disease is expected to increase with increasing temperatures above 59.9°F (McCullough 1999).

The temperature thresholds for each CCV steelhead life stage (with life-stage timing noted) are summarized in Table 98, where the monthly average water temperatures under the proposed action are described for the mouth of the Stanislaus River. Because the modeled monthly temperatures are lower than the maximum daily temperatures most relevant for evaluating 7DADM criteria (EPA 2003), this analysis likely underestimates temperature-related impacts to CCV steelhead in the San Joaquin River. In Table 98, a single-asterisk indicates month/year type combinations in which monthly water temperatures would be expected to exceed the temperature criterion. Double-asterisks indicate month/year type combinations in which the life stage is not expected to be present in the San Joaquin River.

Table 98. Modeled water temperature suitability under the proposed action (Alt2v1) for California Central Valley steelhead by life stages

A single asterisk (*) reflects an average monthly modeled temperature greater than the stressor-specific temperature threshold. Two asterisks (**) reflect an expected low level of exposure based on life stage.

Statistic	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Adult steelhead (September–March) susceptibility to disease and pathogens 57.2°F												
Wet (22%)	59*	55	51	51	51	55	56**	58**	64**	72**	69**	64*
Above Normal (12%)	60*	55	50	50	51	56	56**	60**	68**	73**	73**	70*
Below Normal (15%)	60*	55	51	50	52	56	58**	61**	68**	74**	73**	70*
Dry (17%)	61*	56	51	51	53	59*	61**	65**	71**	75**	74**	70*
Critical (34%)	62*	56	51	50	54	60*	63**	66**	71**	75**	73**	70*
Adult steelhead (September–March) migrating or holding temperatures above 62.6°F												
Wet (22%)	59	55	51	51	51	55	56**	58**	64**	72**	69**	64*

Statistic	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Above Normal (12%)	60	55	50	50	51	56	56**	60**	68**	73**	73**	70*
Below Normal (15%)	60	55	51	50	52	56	58**	61**	68**	74**	73**	70*
Dry (17%)	61	56	51	51	53	59	61**	65**	71**	75**	74**	70*
Critical (34%)	62	56	51	50	54	60	63**	66**	71**	75**	73**	70*
Juvenile steelhead (February–June) impaired smoltification above 53.6°F												
Wet (22%)	59**	55**	51**	51**	51	55*	56*	58*	64*	72**	69**	64**
Above Normal (12%)	60**	55**	50**	50**	51	56*	56*	60*	68*	73**	73**	70**
Below Normal (15%)	60**	55**	51**	50**	52	56*	58*	61*	68*	74**	73**	70**
Dry (17%)	61**	56**	51**	51**	53	59*	61*	65*	71*	75**	74**	70**
Critical (34%)	62**	56**	51**	50**	54*	60*	63*	66*	71*	75**	73**	70**
Juvenile steelhead non-core rearing (December–May) susceptibility to disease and pathogens 59.9°F												
Wet (22%)	59**	55**	51	51	51	55	56	58	64**	72**	69**	64**
Above Normal (12%)	60**	55**	50	50	51	56	56	60*	68**	73**	73**	70**
Below Normal (15%)	60**	55**	51	50	52	56	58	61*	68**	74**	73**	70**
Dry (17%)	61**	56**	51	51	53	59	61*	65*	71**	75**	74**	70**

Statistic	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Critical (34%)	62**	56**	51	50	54	60*	63*	66*	71**	75**	73**	70**

Water temperatures at the confluence of the Stanislaus and San Joaquin rivers are mostly unsuitable for rearing in late spring under the proposed action (Alt2v1), especially in drier years. Water temperatures at the mouth of the Stanislaus River are likely to be stressful to out-migrating CCV steelhead, or even serve as a barrier to migration. In September and October, water temperatures would be high enough to increase adult susceptibility to disease and pathogens. Likewise, juveniles will experience temperatures high enough to impair smoltification from March through June, and an increased susceptibility to disease and pathogens from March through April, particularly in the drier year types. Table 99 summarizes the effects of the proposed action on water temperature and the effects to CCV steelhead in the San Joaquin River.

Table 99. Information used to identify effects of the proposed action on water temperature on California Central Valley steelhead as a result of East Side Division operations in the San Joaquin River.

Stressor	Life Stage (Location)	Life Stage Timing (Work Window Intersection)	Individual Response and Rationale of Effect	Severity of Stressor	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence
Water Temperature (Migration cues)	Adult (Lower San Joaquin River)	September - March	Elevated temperatures can cause a barrier to migration or delay	Minor	Small	High	Low	Medium
Water Temperature (pathogens and disease)	Adult (Lower San Joaquin River)	September - March	Elevated temperatures can increase susceptibility to pathogens and disease	Minor	Small	High	Low	Medium
Water Temperature (Migration cues)	Juvenile (Lower San Joaquin River)	December - May	Elevated temperatures can cause a barrier to migration or smoltification	Minor	Large	High	Medium	Medium

Stressor	Life Stage (Location)	Life Stage Timing (Work Window Intersection)	Individual Response and Rationale of Effect	Severity of Stressor	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence
Water Temperature (pathogens and disease)	Juvenile (Lower San Joaquin River)	December - May	Elevated temperatures can increase susceptibility to pathogens and disease	Minor	Large	High	Medium	Medium

7.4.3.1.2. Flow Condition

The effects of East Side Division operations in the Lower San Joaquin River under the proposed action are described below. See the Effects of the Action on Species in the Stanislaus River section for a detailed discussion of how East Side Division operations on the Stanislaus River affect the flows entering the San Joaquin River. Table 100 shows average monthly modeled flows at Vernalis for the proposed action.

Table 100. San Joaquin ("60-20-20") monthly average flow (cubic feet per second) at Vernalis for the proposed action.

Statistic	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
10% Exceedance	3,383	2,669	5,030	9,790	15,579	14,422	13,658	12,904	8,757	4,091	2,580	2,835
20% Exceedance	2,562	2,272	2,808	5,088	9,248	8,806	9,444	7,661	4,325	2,520	1,773	1,677
30% Exceedance	2,097	1,995	2,059	3,648	5,902	7,175	7,937	5,095	2,954	1,705	1,481	1,388
40% Exceedance	1,857	1,826	1,777	2,736	4,139	4,539	6,342	4,127	2,379	1,611	1,368	1,327
50% Exceedance	1,750	1,617	1,624	2,168	3,000	2,788	3,752	2,950	1,852	1,352	1,140	1,181
60% Exceedance	1,572	1,439	1,525	1,900	2,387	2,518	2,920	2,233	1,524	1,184	1,008	1,068
70% Exceedance	1,472	1,361	1,403	1,749	2,169	2,214	2,607	2,066	1,416	1,033	939	995
80% Exceedance	1,398	1,270	1,296	1,688	1,974	2,061	2,302	1,808	1,258	758	822	907
90% Exceedance	1,296	1,222	1,199	1,574	1,834	1,950	2,077	1,550	1,111	613	669	779
Full Simulation Period Average	2,060	1,969	2,882	4,602	6,441	6,055	6,356	5,637	3,471	1,864	1,432	1,429
Wet Water Years (22%)	3,458	3,243	4,138	10,495	14,859	14,281	14,060	13,738	9,228	4,310	2,764	2,641
Above Normal Years (12%)	2,210	1,994	4,416	5,797	8,410	7,492	8,015	5,673	3,032	1,693	1,307	1,329
Below Normal Years (15%)	1,872	1,806	2,492	4,140	6,686	5,399	6,606	4,453	2,597	1,625	1,356	1,265
Dry Years (17%)	1,563	1,564	2,679	2,075	2,370	2,808	3,173	2,430	1,580	1,163	997	1,025
Critical (34%)	1,409	1,391	1,723	1,835	2,227	2,139	2,267	1,714	1,233	799	867	953

Source: (U.S. Bureau of Reclamation 2023-2024)

Exposure

Life history timing of CCV steelhead adults and juveniles in the mainstem San Joaquin River is described in the Status of the Species section, where adults are expected in the Lower San

Joaquin River from September through March. Juvenile CCV steelhead may be present in the Lower San Joaquin River from roughly December to May as they exit natal river reaches.

Response

The flow-related effects from seasonal conditions in the Lower San Joaquin River will expose CCV steelhead to potential migration delays due to altered frequency and magnitude of hydrologic migration cues. For adult CCV steelhead migrating upriver to spawn, the steelhead response to altered flow conditions is reflected in the relative change in flow, considered here as a surrogate for a change in fitness affecting spawning success. Specifically, the proposed storing and diverting of water would decrease one of a number of the homing cues that influence the successful migration of adult CCV steelhead. Ultimately, the adult CCV steelhead response to an increase in the flow stressor (i.e., decreased flow and a decrease in migration cues) could result in reduced spawning success. Likewise, the conceptual understanding of juvenile CCV steelhead life history is that juveniles will key into flows to facilitate downstream migration (Sandstrom et al. 2020). However, there is little evidence to support a linear relationship between increased flow and improved adult salmonid migration (Peterson et al. 2016) and juvenile riverine migration success (Buchanan and Skalski 2020).

Under the proposed action, the average monthly flows in the Lower San Joaquin River (at Vernalis) would range from 1,429 to 6,441, depending on month and water year type. These managed flows are expected to occur annually resulting in a high frequency of exposure.

Table 101 summarizes the effects of flow conditions caused by the seasonal conditions under the proposed action on CCV steelhead in the San Joaquin River.

Table 101. Information used to identify the effects of the proposed action on flow condition on California Central Valley steelhead as a result of East Side Division operations in the San Joaquin River.

Stressor	Life Stage (Location)	Life Stage Timing (Work Window Intersection)	Individual Response and Rationale of Effect	Severity of Stressor	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence
Flow Condition (Migration cues)	Adult (Lower San Joaquin River)	September - March	Increased flow can improve migration survival (uncertain)	Small	Large	High	Low (uncertain)	Low
Flow Condition (Migration cues)	Juvenile (Lower San Joaquin River)	December - May	Increased flow can improve migration survival (uncertain)	Small	Large	High	Low (uncertain)	Low

Table 102 describes the life stages, primary stressors and effect pathways, and relevant management actions for each operational season on the San Joaquin River for CCV steelhead. The purpose of Table 102 is to succinctly summarize the primary consequences of the proposed action without comparison to other scenarios or conditions. These effects that are summarized in Table 102 also will be carried forward to the Integration and Synthesis section of the opinion.

Table 102. California Central Valley steelhead summary of primary affected life stages, primary stressors/effect pathways, and relevant management actions for seasonal operations periods under the proposed action. These are the elements that will be incorporated into the Integration and Synthesis section of the opinion.

Division/Water body	Seasonal Operations Period	Affected Life Stage	Summary of Primary Stressors and Effects of the Proposed Action	Relevant Management Actions
San Joaquin River - Stanislaus River to Vernalis	Fall, Winter, and Spring Operations	Adults	Water temperature ● Exceeds thresholds for increased virulence 12% to 34% of time with low rate in above normal years and the highest in critical years ● Exceeds thresholds for impairing upstream migration in 12% to 34% of time with lowest rate in above normal years and the highest in critical years	From the Stanislaus: Minimum instream flows, Winter Instability Flows, Spring Pulse Flows, Stanislaus Watershed Team
			Flow Conditions ● Building storage on the Stanislaus River may impair upstream migration cues	From the Stanislaus: Minimum instream flows, Winter Instability Flows, Spring Pulse Flows, Stanislaus Watershed Team
		Juveniles	Water temperature ● Exceeds thresholds for increased virulence 12% to 34% of time with lowest rate in above normal years and the highest in critical years	From the Stanislaus: Minimum instream flows, Winter Instability Flows, Spring Pulse Flows, Stanislaus Watershed Team

Division/Water body	Seasonal Operations Period	Affected Life Stage	Summary of Primary Stressors and Effects of the Proposed Action	Relevant Management Actions
			Flow Conditions ● Building storage on the Stanislaus River may impair upstream migration cues	From the Stanislaus: Minimum instream flows, Winter Instability Flows, Spring Pulse Flows, Stanislaus Watershed Team

7.4.3.2. Central Valley Spring-Run Chinook Salmon Exposure and Response

Although the Lower San Joaquin River is not designated critical habitat for CV spring-run Chinook salmon, this reach of the river is a migratory corridor for those fish that are part of the SJRRP, and those that may migrate to or from the Stanislaus River. New data and information suggest passive reestablishment of CV spring-run Chinook salmon throughout the San Joaquin River basin (Franks 2014, Johnson 2016, Gutierrez et al. 2024). In addition, a genetics report by (Clemento and Garza 2023) concluded that Chinook salmon of spring-run ancestry were identified in the San Joaquin River tributaries.

Based on CV spring-run Chinook adult and juvenile migration timing, adult CV spring-run Chinook salmon presence in the Lower San Joaquin River is assumed to occur from March through June, with juvenile rearing from November through May for juveniles that emigrate as young-of-year and year-round for juveniles that emigrate as yearlings. NMFS expects that any CV spring-run Chinook salmon that may be in the Lower San Joaquin River would experience similar exposure as CCV steelhead. Based on observations and seasonal timing, most juvenile Chinook salmon out-migrate from the San Joaquin River basin during periods when temperatures and dissolved oxygen levels are suitable, such that NMFS expects an exposure and response similar to that experienced by CCV steelhead. Although there is little information on CV spring-run Chinook salmon rearing in this reach of the river, access to habitat and food/prey mediated by flow in most water year types is likewise expected to have a pattern of exposure and response that is similar to CCV steelhead.

Table 103 describes the life stages, primary stressors and effect pathways, and relevant management actions for each operational season on the San Joaquin River for CV spring-run Chinook salmon. The purpose of Table 103 is to succinctly summarize the primary consequences of the proposed action without comparison to other scenarios or conditions. These effects that are summarized in Table 103 also will be carried forward to the Integration and Synthesis section of the opinion.

Table 103. Central Valley spring-run Chinook salmon summary of primary affected life stages, primary stressors/effect pathways, and relevant management actions for seasonal operations periods. These are the elements that will be incorporated into the Integration and Synthesis section of the opinion.

Division/Water body	Seasonal Operations Period	Affected Life Stage	Summary of Primary Stressors and Effects	Relevant Management Actions
San Joaquin River - Stanislaus River to Vernalis	All Seasons	All freshwater life stages	Effects are similar as those described for California Central Valley steelhead, however the status of Central Valley spring-run Chinook salmon in the Stanislaus River is not well understood. The occurrence of individuals has been documented and there is no current evidence of an extant population.	From the Stanislaus: Minimum instream flows, Winter Instability Flows, Spring Pulse Flows, Stanislaus Watershed Team

7.4.3.3. Southern Distinct Population Segment of Green Sturgeon Exposure and Response

The catch of sDPS green sturgeon reported in the San Joaquin River by the Sturgeon Fishing Report Cards[20] and the verified observation of an sDPS green sturgeon on the Stanislaus River (Anderson 2018) confirm a limited presence in the Lower San Joaquin River.

Although the presence and behavior of sDPS green sturgeon in the San Joaquin River is poorly understood, the use of this reach of the San Joaquin River may only be opportunistic. The mechanisms by which the proposed action could result in a probable change in fitness would be similar to those discussed in the Sacramento Division, where flow and temperature analyses are provided for juvenile sDPS green sturgeon. As described here, in the analysis of the East Side Division, the proposed action is expected to reduce peak flows but provide high stable flows in the majority of water year types. Given the timing of juvenile, sub-adult, and non-spawning adult presence in the Lower Sacramento River (July through October) and the estuary (June through November), it is unlikely that peak use of the San Joaquin River by sDPS green sturgeon juveniles would overlap with the most pronounced effects of the proposed action. Some individuals may be exposed to more homogeneous flows and increased temperatures. The combined effect of the low variability in flow and increased temperature will result in an overall decrease in suitable rearing habitat, which would, in turn, cause small reductions in the survival or growth of a small number of individuals.

[20] Available at the CDFW Bay Delta Region sturgeon data bibliography page here: https://wildlife.ca.gov/Conservation/Delta/Sturgeon-Study/Bibliography

7.4.4. Effects of the Action on Critical Habitat in the San Joaquin River

Consistent with Section 7.4.3, which describes the effects to species in the San Joaquin River, the analysis in this section is limited in geographic extent to the San Joaquin River from the confluence with the Stanislaus River, downstream past Vernalis to approximately Mossdale. Designated critical habitat exists in this reach of the San Joaquin River for CCV steelhead and from Vernalis to Mossdale for sDPS green sturgeon.

7.4.4.1. Effects to California Central Valley Steelhead Designated Critical Habitat

The CCV steelhead critical habitat in the San Joaquin River is limited upstream of Mossdale to the confluence with the Stanislaus River. The physical or biological features of critical habitat in this reach of the San Joaquin River include freshwater rearing areas and freshwater migration corridors. This analysis of the proposed action effects on CCV steelhead critical habitat is based on information presented in the preceding section regarding its effects on CCV steelhead, and are summarized in Table 104 as they relate to the physical or biological features of critical habitat.

7.4.4.1.1. Freshwater Rearing Habitat for Juveniles

Operations under the proposed action would limit the extent of peak flows in the wet water year types that would otherwise maintain floodplain connectivity and provide for physical habitat conditions that support juvenile growth and mobility. Likewise, the lack of flow fluctuation and channel-forming flows has reduced habitat complexity, including undercut banks and side channels. Proposed operations will continue this degradation of rearing habitat conditions; however, they will also maintain higher, stable flows throughout the majority of water year types.

7.4.4.1.2. Freshwater Migratory Corridors for Out-Migrating Juveniles and Spawning Adults

Operations under the proposed action will result in temperatures in the migration corridor of the San Joaquin River that are warmer than suitable for juvenile life stages, particularly from March through June. Likewise, flow management will result in lower peak flows compared to the natural hydrograph but will provide for higher base flows in most water year types and in particular during the dryer water year types. These conditions are expected to result in a mixed effect on migration travel times, reducing the function of these areas as migration corridors that is largely a reflection of conditions consistent with the obligated release scenario.

7.4.4.1.3. Summary of Effects to Critical Habitat in the Stanislaus River

Table 104 summarizes the effects of the proposed action on CCV steelhead designated critical habitat in the Lower San Joaquin River.

Table 104. Information used to identify effects of the proposed action to critical habitat in the lower San Joaquin River.

Action Component	Location of Effect	Physical and Biological Features (PBFs) Affected	Response and Rationale of Effect	Magnitude of Effect	Weight of Evidence
Seasonal Conditions	Mossdale upstream to the San Joaquin River Restoration Program area	Rearing Habitat	Reduced peak flows limiting rearing habitat diversity	Minor	Low
Seasonal Conditions	Mossdale upstream to the San Joaquin River Restoration Program area	Freshwater Migratory Corridors	Stable flows provide connectivity but high temperatures can block migration	Small, Minor	Medium

7.4.4.2. Effects to Southern Distinct Population Segment of Green Sturgeon Designated Critical Habitat

Southern DPS green sturgeon have been observed in this reach of the San Joaquin River as reported in the CDFW Sturgeon Fishing Report Cards. However, there is no evidence of sDPS green sturgeon spawning in the Lower San Joaquin River, so the physical or biological features most associated with spawning (substrate type or size, water flow, water quality) are not considered with regard to spawning or egg incubation. The anticipated impacts to sDPS green sturgeon freshwater rearing and migratory habitat are similar to those discussed for salmonids in Section 7.4.4.1.2 Freshwater Migratory Corridors for Out-Migrating Juveniles and Spawning Adults. Overall, stable, springtime flows and warm water temperatures are expected to predominate and degrade the conservation value of the habitat with respect to the physical or biological features of water flow, water quality, and migratory corridor.

7.5. Bay-Delta Division

7.5.1. Effects of the Action on Species in the Bay-Delta Division

NMFS deconstructed the proposed action to identify the project components and determine the effects pathways in the Bay-Delta Division (Figure 108). The proposed action includes other project components that are also Delta-related, however they are described and analyzed at a

"framework programmatic" level of detail separately in Section 7.9 of this opinion. Key Bay-Delta Division facilities are shown in Figure 109. NMFS evaluated the potential effects of those project components on stressors that may affect listed species, then analyzed the exposure and response of each species to the project-related stressors affected by each proposed action component. To capture key details of the proposed action to provide convenient context for the effects analysis, some of the text describing the proposed action component may be nearly verbatim from the October 2024 proposed action chapter of the BA (U.S. Bureau of Reclamation 2023-2024), with some edits for brevity and with figure and table numbering modified to fit within the numbering of this section of the opinion. Because the edits are scattered throughout, NMFS does not include those verbatim portions in quotation marks but acknowledges here the significant reliance on the wording in the BA. The full October 2024 proposed action is provided as Appendix A of this opinion. The modeling summaries also rely heavily on the material in the appendices to the BA, again not always with explicit attribution.

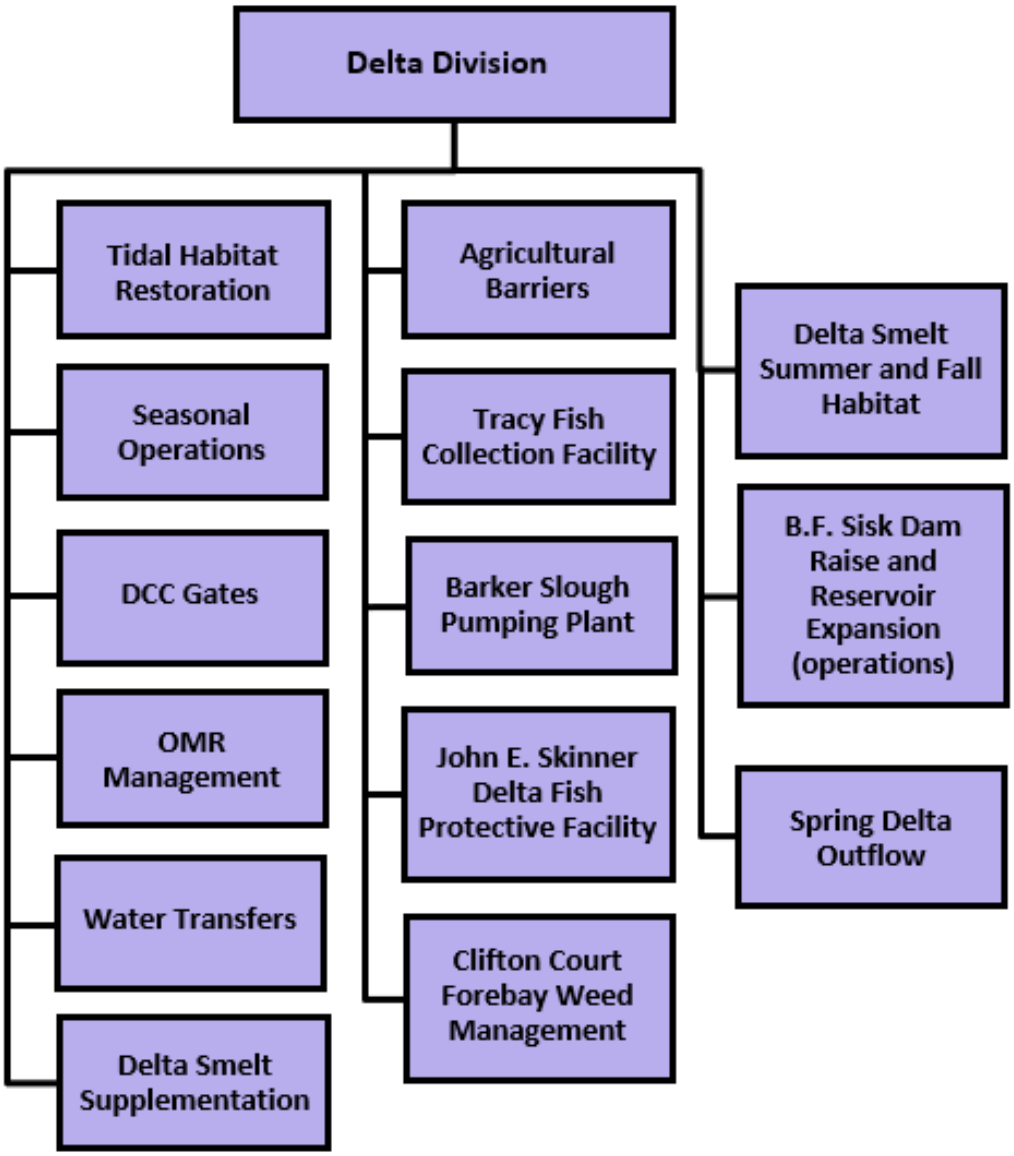


Figure 108. Deconstruction of the proposed action elements in the Bay-Delta Division.

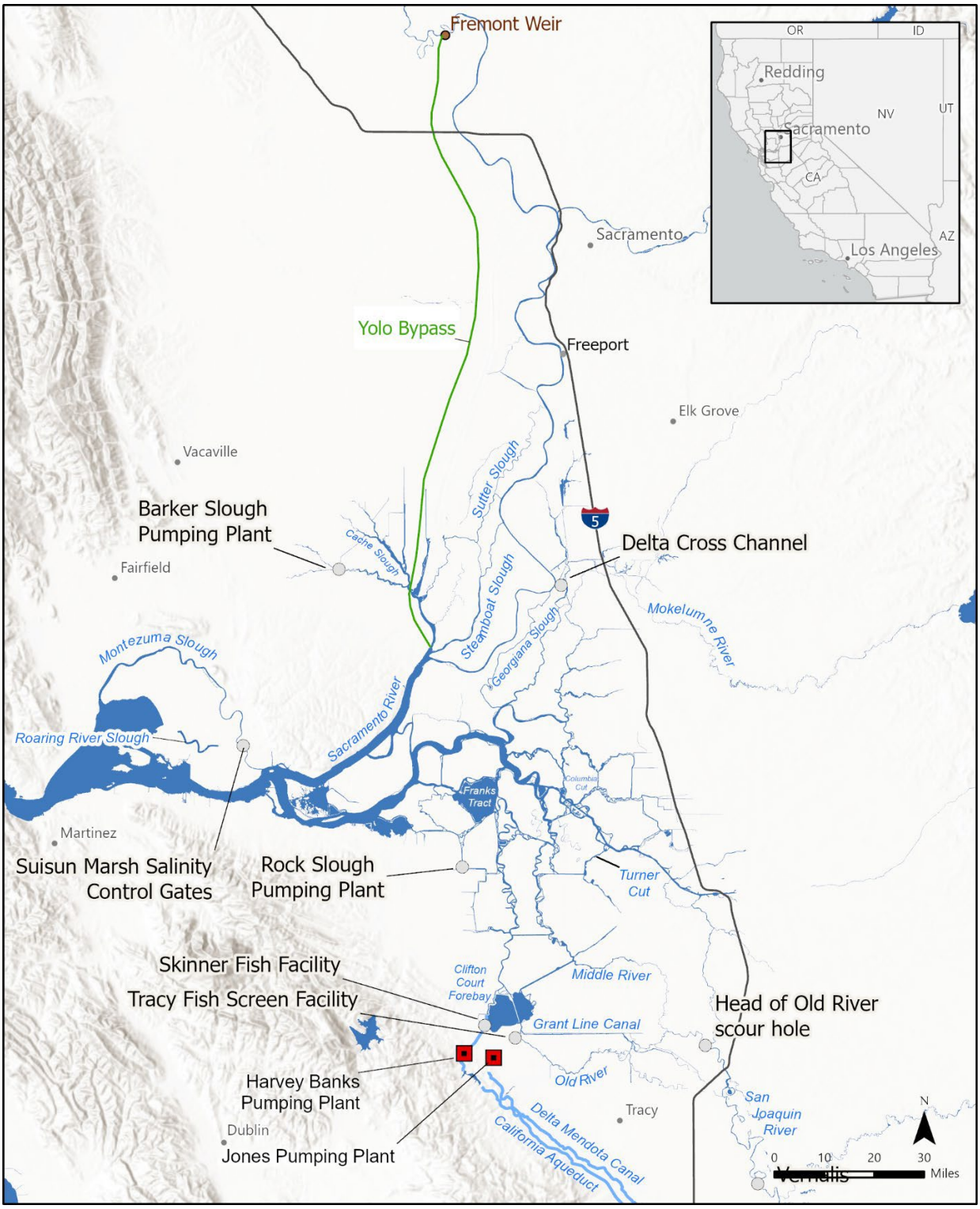


Figure 109. Map of key Bay-Delta Division facilities.

Source: (U.S. Bureau of Reclamation 2023-2024)

As described in our Analytical Approach section, and consistent with the BA (U.S. Bureau of Reclamation 2023-2024), NMFS structures our effects analysis around the SAIL conceptual models in (Windell et al. 2017). Those models identify a variety of stressors (e.g., environmental drivers and habitat attributes) by species and life stage, as summarized in Appendix D of the BA (U.S. Bureau of Reclamation 2023-2024).

Because of the complexity of the Bay-Delta and the many interacting effects pathways, the stressors considered in this analysis focus on the environmental drivers of water flow, passage impediments/barriers and the habitat attributes of entrainment. Entrainment may be used both in the context of entrainment into a particular out-migration route (for example, entrainment from the mainstem Sacramento River into the interior Delta via the Delta Cross Channel) and in the context of entrainment into the export facilities in the South Delta.

Table 105 provides a summary of each project component identified in the deconstructed action for the Bay-Delta Division (Figure 108) as to their potential influence on a particular stressor. The exposure and response to individuals of SR winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon are then analyzed in the following sections for each project component. Because much of the modeling in the BA provides outputs in terms of through-Delta survival or salvage or loss at the South Delta export facilities for the proposed action as a whole, it is seldom possible to tease out specific incremental contributions of individual project components to the responses of through-Delta survival or salvage or loss. Therefore, while this section does describe how each project component is expected to affect salmonids and sturgeon, we take a simplified approach to the tabular summaries compared to the analysis in other divisions.

Table 105. Stressors evaluated in the analysis of effects of the proposed action in the Bay-Delta Division.

Project Component	Passage Impediments /Barriers	Water Flow	Entrainment
Seasonal Operations		X	X
Delta Cross Channel (Gate closures and gate maintenance and repair)	X	X	X
Old and Middle River Management		X	X
Spring Delta Outflow		X	X
Delta Smelt Summer and Fall Habitat		X	
Tracy Fish Collection Facility		X	X
John E. Skinner Delta Fish Protective Facility		X	X
Tidal Habitat Restoration			
Delta Smelt Supplementation			
Water Transfers		X	X
Agricultural Barriers	X	X	
Barker Slough Pumping Plant		X	X

Project Component	Passage Impediments /Barriers	Water Flow	Entrainment
Clifton Court Forebay Weed Management			
B.F. Sisk Dam Raise and Reservoir Expansion (operations)		X	X

An "X" indicates that the action component affects a stressor category; the response could be negative or positive.

Although the BA modeled six scenarios, the two scenarios which best represent the proposed action are considered in this effects analysis for the Bay-Delta Division:

- **Alt2v1:** Alternative 2 v1 – Does not include any VA elements. Many of the figures from the BA label this scenario "Alt2woTUCPwoVA."
- **Alt2v2:** Alternative 2 v2 – (pre-adoption of the VAs) – Includes the Delta VA element of CVP and SWP foregone exports March-May. Many of the figures from the BA label this scenario "Alt2woTUCPDeltaVA."

The proposed action includes two phases: Alt2v1, and Alt2v2. Alt2v2 would occur for approximately the first 2 years of project implementation (Reclamation may continue this action for longer than 2 years if substantial progress is being made to approve VAs, but they are not yet incorporated into the SWRCB's Water Quality Control Plan), and Alt2v1 would occur for the remainder of years. Neither modeled scenario (Alt2v1 or Alt2v2) captures the proposed phasing of operations, so this section evaluates both scenarios to assess the potential effects expected during each phase.

- For the first phase of the proposed action, Alt2v2 represents the conditions (flow, storage, etc.) due to the proposed action with the pre-adoption of the Delta contribution to the VA for 2 years. For the second phase of the proposed action, Alt2v1 represents the proposed action without the contribution of any VA assets.
- In October 2024, NMFS received a clean version of the proposed action with all final modifications (U.S. Bureau of Reclamation 2023-2024), included in this opinion as Appendix A). Most revisions clarified intended processes or modified proposed operations in ways that are still captured reasonably in the modeling scenarios. The following revisions pertain to Spring Delta Outflow, as summarized in Table 106, below.
    - For the pre-adoption period, Reclamation and DWR propose to support the Spring Delta Outflow action during March through May, with an emphasis on April and May, with water made available by the CVP and SWP.
    - DWR's pre-adoption action will be in place until the VAs are incorporated into their Water Quality Control Plan and the VA parties execute agreements.
    - Reclamation and DWR propose to operate consistent with the post-adoption action described in the BA (U.S. Bureau of Reclamation 2023-2024) only if the SWRCB approves the VAs as substantially proposed by the VA parties, and the parties execute or are in the process of executing the agreements associated with the VAs and the SWRCB incorporates the VAs as proposed into their Water Quality Control Plan.

- Reclamation added the DWR commitment to an extension of foregone SWP exports past 2 years by operating to their proportional share of the inflow to export ratio, and modified the SWP export limits in all years pre-adoption of the VAs to be based on ITP requirements (California Department of Fish and Wildlife 2024c) rather than the Delta VA table.
- On October 15, 2024, Reclamation proposed that they may continue this pre-adoption action for longer than 2 years if substantial progress is being made to approve VAs, but they are not yet approved. This is a minor adjustment, and we did not modify our analysis to reflect a possible extension past year 2, although it is possible that the effects of the action could continue for more than 2 years.

Table 106. Description of proposed action phase, operational assumptions, and representative modeling scenario.

Version and Phase of the Proposed Action	Central Valley Project (CVP)	State Water Project (SWP)	CalSim Modeling Scenario
November 2023 – pre-adoption of the Voluntary Agreements (VAs; years 1 and 2)	CVP foregone exports based on the Delta VA table (Table 129, Spring Delta Outflow section).	SWP foregone exports based on the Delta VA table.	Alt2v2
October 2024 – pre-adoption of the VAs (years 1 and 2)	CVP foregone exports based on the Delta VA table (Table 129, Spring Delta Outflow section).	SWP foregone exports based on the operations described in the Incidental Take Permit application (California Department of Fish and Wildlife 2024c), which are "VA-like" but are based on Condition 8.17 of the 2020 ITP, and thus aren't exactly as modeled in Alt2v2.	No independent modeling scenario provided. Conditions in the Delta are likely similar to Alt2v2.
November 2023 – after 2 years if VAs not adopted	No CVP foregone exports.	No SWP foregone exports.	Alt2v1
October 2024 – after 2 years if VAs are not adopted, and Reclamation does not continue foregone exports.	No CVP foregone exports.	SWP foregone exports based on the operations described in the Incidental Take Permit application (California Department of Fish and Wildlife 2024c), which are "VA-like" but are based on Condition 8.17 of the 2020 Incidental Take Permit, and thus aren't exactly as modeled in Alt2v2.	No independent modeling scenario provided. Conditions in the Delta in March-May likely intermediate to Alt2v1 and Alt2v2.

Version and Phase of the Proposed Action	Central Valley Project (CVP)	State Water Project (SWP)	CalSim Modeling Scenario
October2024 – after 2 years if VAs are not adopted, and Reclamation does continue foregone exports.	CVP foregone exports based on the Delta VA table (Table 129, Spring Delta Outflow section).	SWP foregone exports based on the operations described in the Incidental Take Permit application (California Department of Fish and Wildlife 2024c), which are "VA-like" but are based on Condition 8.17 of the 2020 Incidental Take Permit, and thus aren't exactly as modeled in Alt2v2.	No independent modeling scenario provided. Conditions in the Delta likely similar to Alt2v2.

Because there is no CalSim3 modeling scenario that exactly represents either phase of the revised proposed action, NMFS retains the original effects analyses of Alt2v2 and Alt2v1 and understands that those modeling scenarios bound the expected effects under the revised proposed action. Because of DWR's commitment to forego exports beyond year 2, the second phase of the revised proposed action may have less severe impacts to listed anadromous fish in the Delta compared to Alt2v1.

Detailed modeling assumptions for these scenarios are provided in the BA in Appendix F, Sections 1-1 and 1-2 (U.S. Bureau of Reclamation 2023-2024). Some key differences in operational assumptions are summarized in Table 107 and discussed in more detail in the relevant sections of the Bay-Delta Division effects analysis. Because most of the modeling outputs show all modeled scenarios, not just the phases of the proposed action, the table below also describes the assumptions in some key scenarios which are sometimes described in our effects analysis for context.

Table 107. Summary of modeling assumptions for those operational elements with a significant difference between scenarios.

Operational or proposed action element	Alt2v2 (first 2 years)	Alt2v1 (year 3 onward)	NAA (No Action Alternative)	EXP3 (Obligated Release Scenario)
Delta Cross Channel	Same as NAA	Same as NAA	Open part of October–November and June; closed December–May; open during the summer	As if it does not exist; modeled as always closed

Operational or proposed action element	Alt2v2 (first 2 years)	Alt2v1 (year 3 onward)	NAA (No Action Alternative)	EXP3 (Obligated Release Scenario)
CVP water allocations	Same as Alt2v1	Similar to NAA but with some reductions for Shasta management, especially in Bin3B years	See details in BA Appendix F	Settlement/Exchange contractors and refuge water only
Exports at the South Delta export facilities	Same as Alt2v1 but with the Spring Delta Outflow action	Similar to NAA but possibly with some reductions for Shasta management, especially in Bin3B years	See details in BA Appendix F	None
OMR Management – Chinook salmon run ID method	Same as Alt2v1	Based on genetics	Based on length-at-date criteria	Not applicable; no OMR management
OMR Management for Sacramento River winter-run Chinook salmon and California Central Valley steelhead – loss thresholds	Same as Alt2v1	Weekly loss thresholds. Annual loss thresholds with action responses at 50% and 75%. No 10-year cumulative loss thresholds	No weekly loss thresholds Annual loss thresholds with action responses at 50% and 75%. 10-year cumulative loss thresholds	Not applicable; no OMR management
Delta outflow – Delta outflow index	Same as Alt2v1	CVP & SWP: D-1641 and Fall X2 in above normal and wet year types	CVP & SWP: D-1641 and Fall X2 in above normal and wet year types SWP only: ITP requirements modeled as SWP providing up to 150 TAF of outflow in April and May and 100 TAF in June-September of above normal and wet year types	D-1641 only

Operational or proposed action element	Alt2v2 (first 2 years)	Alt2v1 (year 3 onward)	NAA (No Action Alternative)	EXP3 (Obligated Release Scenario)
Spring Delta Outflow – Delta VA	CVP and SWP foregone export volumes (Table 129, Spring Delta Outflow section) in March–May	None	None	None
B.F. Sisk Dam Raise	Same as Alt2v1	Crest raise increases the maximum storage by 130 TAF to ~2170 TAF.	No crest raise, but storage allowed up to current maximum elevation with ~2040 TAF[a] capacity	No South Delta exports and thus no storage at San Luis Reservoir; dam raise assumptions are irrelevant.

CVP = Central Valley Project; SWP = State Water Project; OMR = Old and Middle rivers; TAF = Thousand Acre-Feet.

[a] In Appendix F, Attachment 1-1, the NAA scenario is described (U.S. Bureau of Reclamation 2023-2024) as including the current size of San Luis Reservoir, with a 972 TAF CVP capacity and 1067 TAF SWP capacity. 972 + 1067 = 2,039 TAF. In Appendix F, Attachment 1-2, the NAA scenario is described (U.S. Bureau of Reclamation 2023-2024) as operating to "existing 2041 TAF capacity."

7.5.1.1. Delta Conceptual Model and Recent Delta Science

Many of the proposed action components in the Bay-Delta affect multiple life stages of salmonids and green sturgeon survival (abundance), timing (migration), and growth (condition) as shown in Figure 110. The many interacting factors also make it hard to isolate or quantify the effect of any one Bay-Delta Division component, especially on "large-scale" effects metrics such as through-Delta survival. Likewise, the correlations among environmental variables add to the challenge of discerning independent effects from those that interact or are interrelated with others. Because of this complexity, conceptual models provide useful tools to follow a particular environmental driver or habitat attribute to the penultimate stressor and subsequent change in individual fitness.

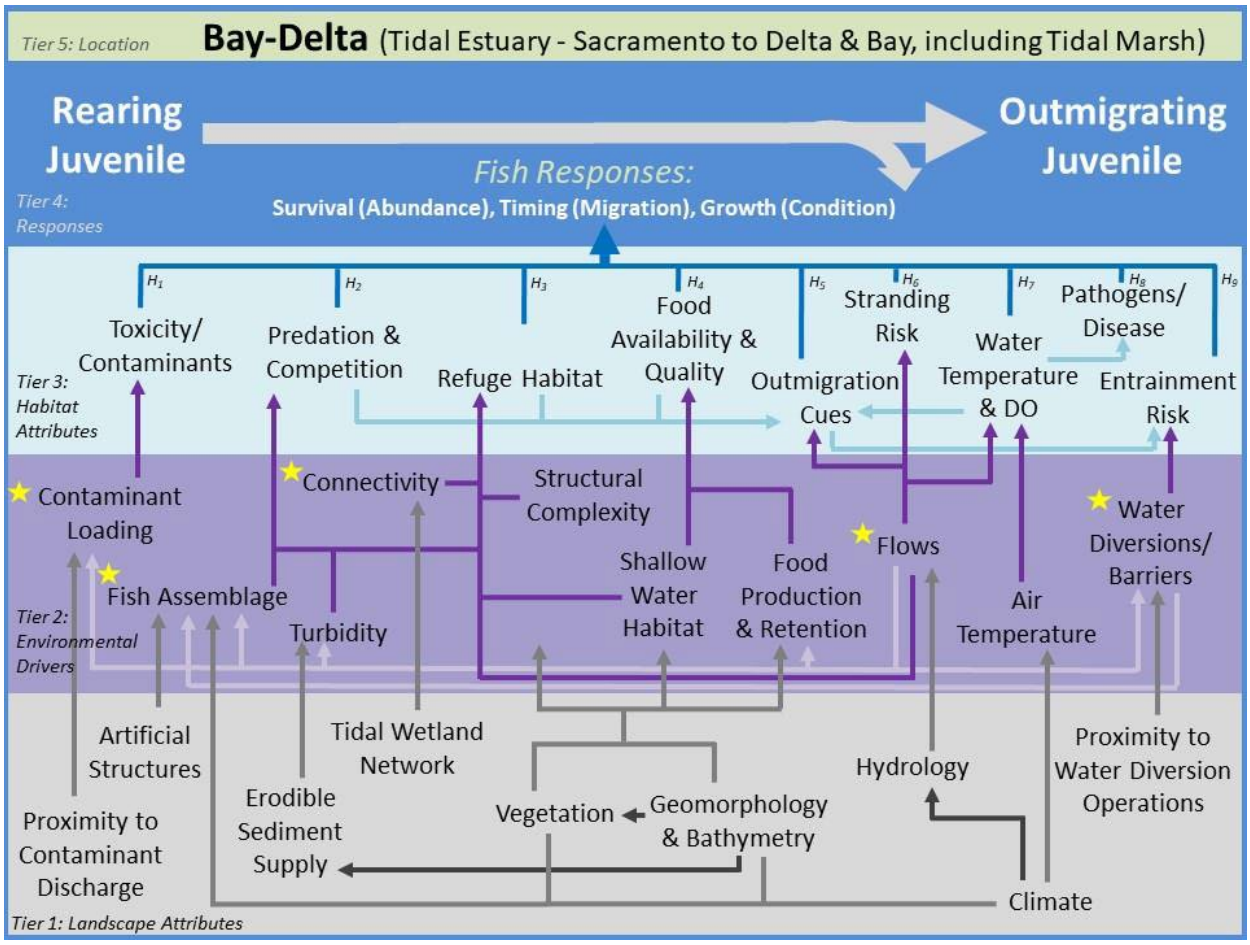


Figure 110. Conceptual model of drivers affecting the transition of Sacramento River winter-run Chinook salmon from rearing juvenile to out-migrating juvenile in the Bay-Delta.

Source: (Windell et al. 2017)

In addition to the SAIL model, NMFS considers several types of water project-related stressors and the physical and biological process effects on salmonids in the South Delta as captured in the conceptual model used in the 2017 SST (Salmonid Scoping Team 2017a, b) reports (Figure 111). The SST conceptual model provides a series of finer-scale linkages between Bay-Delta stressors and processes on juvenile survival to Chipps Island, juvenile condition and fitness, and the timing of juvenile migration and ocean entry. Figure 112 provides an example of the SST framework approach linking Bay-Delta hydrodynamics to salmonid migration behavior and how that will affect survival. NMFS uses both conceptual models to describe effects pathways and parse the effects of the action on individuals of the species.

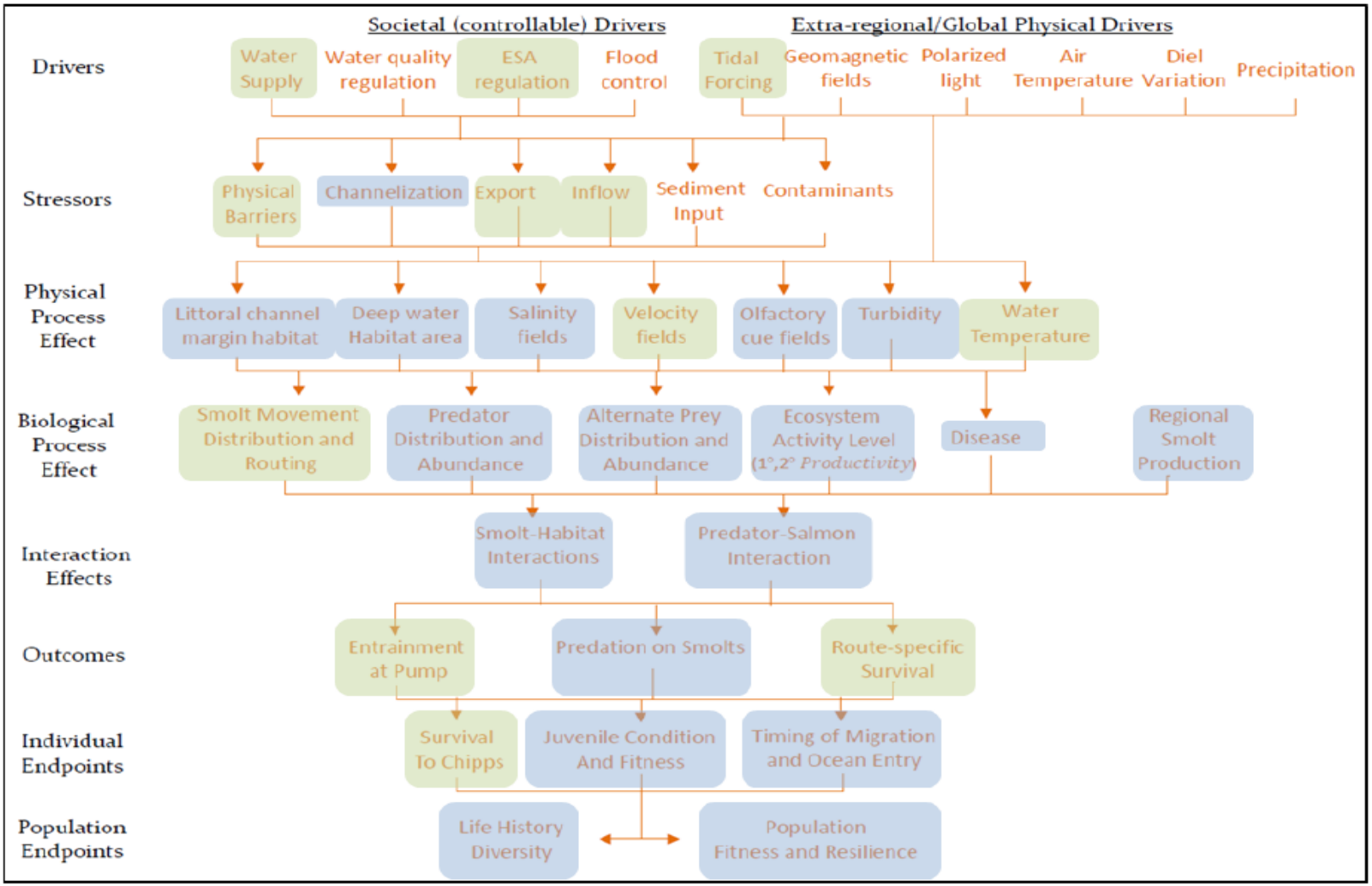


Figure 111. Conceptual model used by the Salmonid Scoping Team describing factors affecting survival of juvenile salmonids in the South Delta.

Source: (Salmonid Scoping Team 2017a)

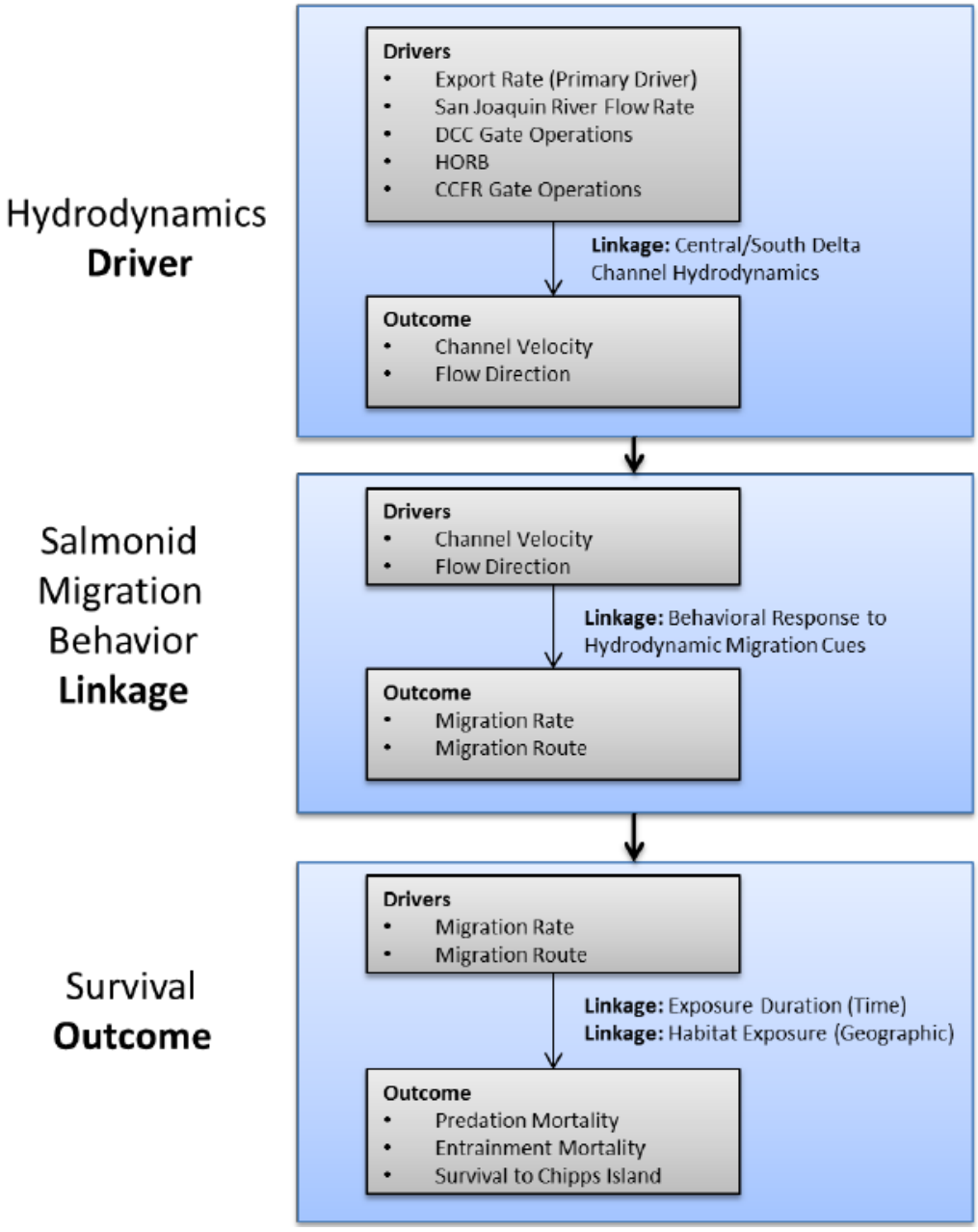


Figure 112. General framework linking hydrodynamic effects of Central Valley Project and State Water Project operations to migration behavior and survival outcome.

Source: (Salmonid Scoping Team 2017a)

The SST report summarizes the science through approximately 2015 that is relevant to the key driver-linkage-outcomes of hydrodynamic effects of project operations (Salmonid Scoping Team 2017a, b; Table 108; Table 109; Table 110).

Table 108. Driver-linkage-outcomes analyzed in Salmonid Scoping Team 2017 related to hydrodynamics.

Drivers	Linkages	Outcomes
• Exports • River inflow (Sacramento and San Joaquin rivers) • Tide • Channel morphology	• Proximity to exports • Channel configuration/barrier deployment • Clifton Court Forebay radial gate operations (e.g., opening to fill forebay and closing to isolate pumping plant operations from the Delta)	• Instantaneous velocities or flows • Net daily flow • Sub-daily velocity • *Percent positive flow • *Water temperature • *Salinity • *Residence time • *Source/origin of water

Note: Asterisked bullets are driver-linkage-outcomes that were not analyzed.

Table 109. Driver-linkage-outcomes analyzed in Salmonid Scoping Team 2017 related to behavior.

Drivers	Linkages	Outcomes

• Instantaneous flow/velocity (channels)
• Instantaneous flow/velocity (junctions)
• *Water quality (e.g., temperature, dissolved oxygen, salinity, turbidity, contaminants)
• *Hydraulic residence time
• Spatial/temporal heterogeneity of hydrodynamic/water quality drivers
• *Small-scale hydrodynamics as affected by structures/bathymetry
	• Physiological and behavioral responses to hydrodynamic or water quality conditions, gradients, or variability, such as:
	  ○ *Rearing
	  ○ *Active swimming
	  ○ Lateral distribution in the channel
	  ○ Passive displacement
	  ○ Diel movements
	  ○ *Energy expenditure
	  ○ *Selective tidal stream transport
		• Individual outcomes:
		  ○ Migration rate
		  ○ Migration route
		  ○ Migration timing
		  ○ *Timing of Delta entry
		  ○ *Delta residence time
		  ○ *Rearing locations
		• Population outcomes:
		  ○ Population-scale outcomes depend on the spatial/temporal heterogeneity of individual outcomes.

Note: Asterisked bullets are driver-linkage-outcomes that were not analyzed.

Table 110. Driver-linkage-outcomes analyzed in Salmonid Scoping Team 2017 related to salmonid survival.

Drivers	Linkages	Outcomes
● Migration route selection ● Migration rate	● Exposure to variables (e.g., habitat and predators) that affect differential survival between routes or between years for the same route ● Duration of exposure to route-specific conditions that affect survival	● Mortality

NMFS incorporates by reference the comprehensive January 2017 report, *Effects of Water Project Operations on Juvenile Salmonid Migration and Survival in the South Delta* (Salmonid Scoping Team 2017a). Written by the SST convened by the Collaborative Adaptive Management Team (which included technical staff from multiple agencies and interested parties), the report provides an overview of the findings and uncertainties related to salmonids and water operations in the South Delta.

Some key assumptions and elements of NMFS' approach to using the conceptual models of salmonid survival in the Delta, in the context of water operations, include:

- Effects of exports outside the facilities likely diminish with distance (Cavallo et al. 2015).
- Near-field effects on fish at the export facilities are the most evident form of project-related direct mortality in the Delta. The hydrodynamic effects from operation of the export facilities are likely to increase fish residence time in some portions of the Central and South Delta, even for fish not entrained into the fish salvage facilities, increasing their exposure to predation and other stressors within the Central and South Delta.
- Far-field effects on fish from export facilities have been difficult to detect but are assumed to affect a greater portion of the population. Velocity and flow changes due to exports are a proxy measure for changed far-field hydrodynamics within the Delta. Depending on location, those hydrodynamic effects may decrease or increase fish residence time in portions of the Central, South, and Eastern Delta; decreasing or increasing their exposure to predation and other stressors within the Central, South and Eastern Delta.
- Near-field effects of the CVP and SWP export facilities, such as entrainment and loss, and far-field effects, such as potential migratory disruptions at junctions or in channels, may be linked to salmonid survival via different mechanisms—so studies at one location may not be applicable Delta-wide. For example, a study that does not show an effect of Old and Middle rivers (OMR) flow on salmonid routing at Turner Cut is not considered as support for no OMR effects on through-Delta migration.

In the analysis of proposed action effects, NMFS considers whether and how different proposed action components may affect the following elements of through-Delta migration and survival, which all have different mechanistic links to flows and exports. These three elements are discussed at a conceptual level in the sections immediately below and relevant model results from the BA are summarized in Section 7.5.1.3 Delta Effects Lines of Evidence. Specific aspects of these effects pathways and model results may be further discussed, when relevant, in the analysis for each proposed action component:

- Routing at junctions on the mainstem Sacramento River and San Joaquin River (e.g., Delta Cross Channel and Head of Old River)
- Movement rates and survival in channel reaches of the mainstem San Joaquin River and the interior channels of the South Delta
- Entrainment into the SWP and CVP fish salvage facilities and loss at those facilities

Additional highlights from selected reports and articles are summarized in Appendix B: Delta Literature. Key conclusions from more recent evaluations of salmonid survival in the Central Valley and Delta include:

- Out-migration survival of salmonid smolts in riverine waterways increases with increasing flow—this result is consistent for Chinook salmon and steelhead from both the Sacramento (Henderson et al. 2019, Notch et al. 2020, Michel et al. 2021) and San Joaquin (Buchanan et al. 2018, Buchanan et al. 2021) river basins.
- Riverine conditions (i.e. with unidirectional downstream flow, rather than tidally reversing flow) are present in the mainstem Sacramento River and San Joaquin River upstream of the Delta, and the extent to which those riverine conditions extend into the Delta increases with inflow from each basin (Cavallo et al. 2013).
- In tidally-reversing channels of the interior Delta, many covariates (Delta inflow, exports, routing, predation, etc.) may affect the survival of salmonids and the evidence for a relationship with flow is more equivocal (Buchanan et al. 2018, Buchanan and Skalski 2020, Buchanan et al. 2021). Studies are hampered by correlation between environmental covariates, complicated routing, little experimental control, and (for Chinook salmon) overall low survival.
- Juvenile salmonids out-migrating from the San Joaquin River basin are particularly vulnerable to the hydrodynamic conditions, including export effects, in the South Delta since all of them experience those conditions (while only a portion of Sacramento River basin fish may reach the South Delta): All fish migrating from the San Joaquin basin (including threatened CCV steelhead and SJRRP CV spring-run Chinook salmon) necessarily transit the South Delta given their entry point to the Delta. In a study of loss of CWT release groups at the export facilities, Zeug and Cavallo (2014) found that the relative loss of San Joaquin River releases was "more than double that of Sacramento River releases at both facilities […] although relative loss was less than 5% for most releases; this value ranged as high as 17.5%."
- The STWG, convened by the CAMT, recently issued a report that reviewed some recent results from studies on salmonid survival in the South Delta (Salmon Technical Working Group 2024). One finding was that "after many years of intensive scientific investigation, we have not observed significant survival improvements for San Joaquin River-origin salmonids, nor have we seen an adverse impact from water export rates on survival under the range of regulatory and environmental conditions studied (e.g., OMR no more negative than -5,000 cfs. See Framing section for more detail)." NMFS emphasizes that the observed combinations of exports and San Joaquin River inflow during survival studies were likely subject to regulatory limits on OMR or inflow-to-export ratio. Therefore, inferences regarding export effects on survival must be limited to the incremental effects beyond the regulatory range. The STWG does acknowledge that their review of recent data "does not necessarily support an inference that existing regulatory tools that limit exports are ineffective," but goes on to say that their review "does suggest

exports are not the primary factor negatively affecting survival of San Joaquin origin salmonids." NMFS considers the latter point insufficiently caveated.

- Managing exports to reduce entrainment risk may negatively impact the survival of juvenile Chinook salmon utilizing the Old River route because it reduces the likelihood of being salvaged and trucked past the Delta. Because trucked fish, re-released in the western Delta would avoid a number of stressors along their migration path it is thought that survival may be higher for those fish. However, because the estimated loss of entrained salmonids is greater at the SWP (4.33 fish lost for every fish salvaged) compared to the CVP (0.68 fish lost for every fish salvaged), and the SWP has greater export capacity (and thus entrainment potential) than the CVP, it is important to consider that survival effects attributed to salvage may relate differently to SWP or combined exports than compared to CVP exports alone. For example, while no export factor was significant at the testwise level (alpha = 0.0042), Buchanan et al. (2021) found that the direction of effect on steelhead survival from the head of Old River to Chipps Island was positive for CVP exports but negative for SWP or combined SWP and CVP exports. However, in Buchanan and Skalski (2020), a similar analysis on Chinook salmon survival found a positive direction of effect on Chinook survival from the head of Old River to Chipps Island (again, within the range of variation beyond regulatory constraints) for both a CVP export term and a combined SWP and CVP export term. More studies and analyses of the effects of juvenile Chinook salmon and steelhead near the diversion facility intakes and northward in the OMR corridor are needed to determine what operational conditions (if any) can improve survival outcomes relative to entrainment and salvage.

7.5.1.1.1. Routing at Junctions on the Mainstem Sacramento River and San Joaquin River

Routing "decisions" occur when a fish reaches a particular junction and where local flow conditions at that time (including tidal effects), rather than daily or longer-term average flows, affect the outcome. Routing at a junction depends on instantaneous flow fields and velocities at the junction in three-dimensional space, the spatial distribution of fish as they enter the region of the junction space, and the individual behavior of the fish to the environmental variables it encounters in this space. In the vast majority of instances, little or no data can be provided with the available tools and with enough granularity that we can evaluate and quantify the specific hydrodynamics at a given junction and time. In light of the absence of this information, the proportional routing of fish is estimated based on longer-term hydrodynamic measures assuming a uniform arrival of fish at the junction throughout the averaging period. On the mainstem San Joaquin River, especially in the tidal reaches downstream of the Head of Old River, flow changes due to the tides are greater than flow changes due to export rates. One way in which high San Joaquin River inflow may improve through-Delta survival is that it moves the region of tidal influence farther downstream and may lead to flow conditions at junctions that reduce routing into the interior Delta.

Ultimately, where a project component may affect the environmental variables at a junction, our conceptual understanding of routing behavior and effect is predicated on the following assumptions:

- Individual fish will enter the junction space over a discrete period of time (daily) and that daily net flows (tidally averaged in tidal regions) will influence the pattern of flow dispersal at the junction over the diurnal tidal cycle in which the fish is present in the junction space
- Stronger downstream flows (more positive daily net flows) will move the tidally influenced zone farther downstream, and the junction will have less water flowing into it, either by magnitude or duration

The extensive work by Perry et al. (2018) parallels this concept, although in much greater detail for the Sacramento River adjacent to the Delta Cross Channel gates where higher flows in the Sacramento River mute the tidal effect and less flow and fish go into the Delta Cross Channel route when the gates are open. Hydrodynamic conditions downstream of the junction have more pronounced riverine characteristics when flows are high and there is less tidal influence in the area of the junction. However, estimates of juvenile salmonid migration route selection and survival through rivers and estuaries have historically been based on statistical models (Newman 2003, Perry et al. 2018, Hance et al. 2022), which only reliably describe patterns over an observed range of conditions. A shortcoming of these models is that they do not include emergent behaviors and are, therefore, unable to accurately predict the individual behavior of the fish in novel hydroclimatological and management conditions. Ongoing development of tools such as ECO-PTM may help to improve the spatial and temporal resolution of assessments of fish responses to Delta flow conditions. Additional discussion of routing is provided in Appendix B of Volume 1 of the 2017 SST report (Salmonid Scoping Team 2017a).

7.5.1.1.2. Movement and Survival in the San Joaquin River and South Delta

Much work in both the North and South Delta focuses on routing at junctions and reach-specific travel-time or survival for release groups of fish that may transit the Delta in a several-week period. However, few early studies (Vogel 2002) have addressed in-channel movements of individuals at finer temporal and spatial scales that may be most appropriate to link to mechanistic models of behavior. Some more recent studies (Buchanan et al. 2018, Buchanan and Skalski 2020, Buchanan et al. 2021) have analyzed reach-specific survival in portions of the South Delta, but even those reach-specific survivals often reflect hydrodynamic conditions over days rather than at a sub-daily temporal scale which is the scale at which individual fish behavior may react to ambient conditions. Since fish likely spend a majority of their time in channels, not at junctions, behaviors in response to flows in Delta channels are also important for understanding migratory behavior. Resulting fish behavior and survival in channels are the primary factors underlying concerns about minimizing disruptions to South Delta hydrodynamics. Although hydrodynamics can be influenced by many factors, the most influential factors in the South Delta are tides, CVP and SWP exports, and inflow from the San Joaquin River to the Delta (usually referred to as “Vernalis inflow”). Of those three factors, exports and Vernalis inflow are the two components for which there are project-related effects. Examples of how exports and Delta inflow (and resulting OMR flow) affect South Delta hydrodynamics are shown in Figure 113.

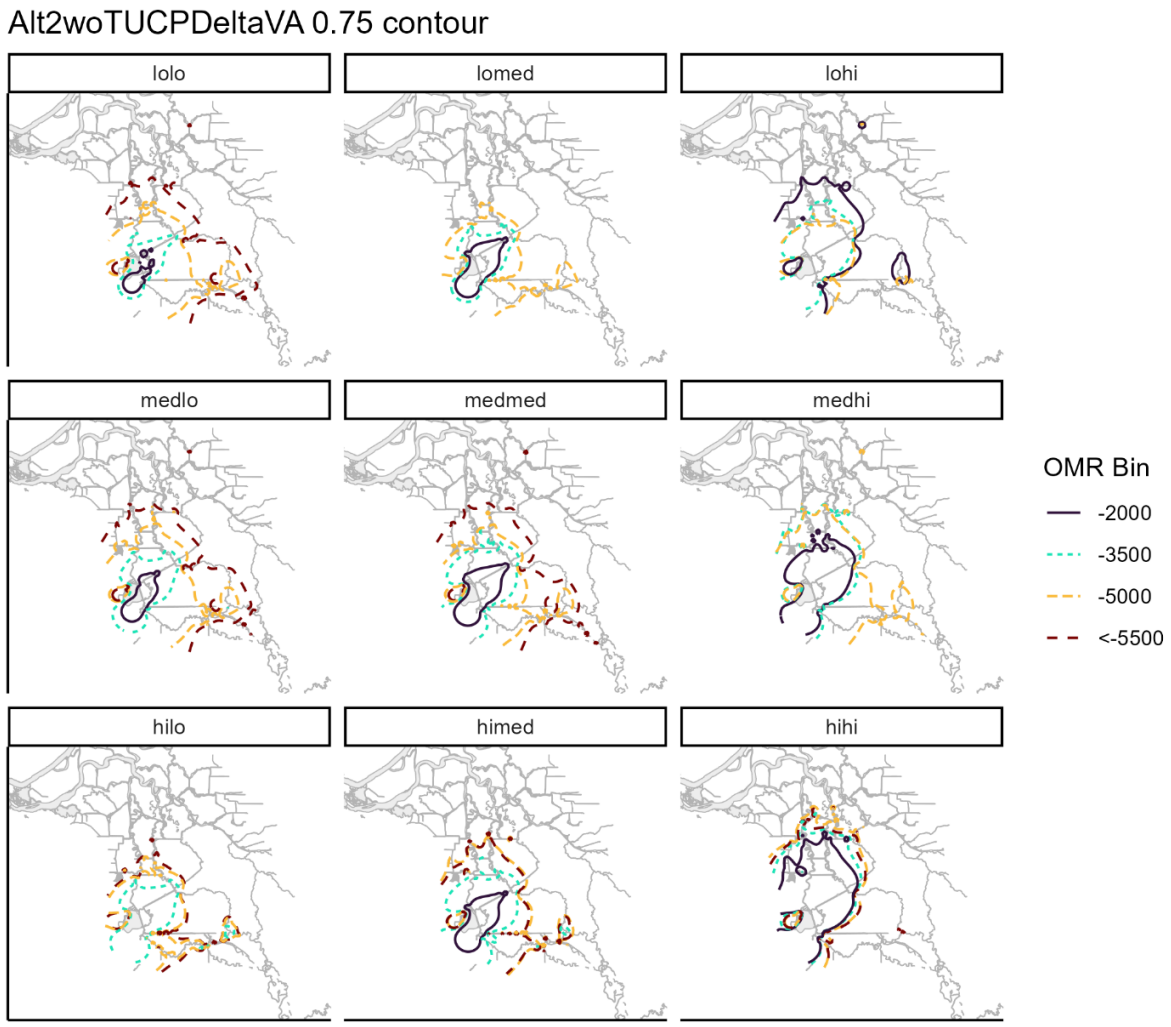


Figure 113. Faceted contour maps delineating Delta Export Zone of Influence under varying inflows and OMR Flows under phase 1 of the proposed action (Alt2woTUCPDeltaVA [Alt2v2]).

The contours identify where there is up to 75% overlap in velocity distribution with and without CVP exports. Inflow groups are labeled with the relative flow range in the Sacramento River followed by the relative flow range in the San Joaquin River. The panels in the first, second, and third rows represent low, medium, and high Sacramento River flows. The panels in the first, second, and third columns represent low, medium, and high San Joaquin River flow.

Source: Figure 9 in LTO Appendix I – Old and Middle River Flow Management; Attachment X, Delta Export Zone of Influence Analysis (U.S. Bureau of Reclamation 2023-2024)

In our analysis, NMFS applied net daily flows as a proxy measure for channel velocity distributions (more negative net daily flow is associated with a velocity distribution that includes more frequent and/or more extreme negative velocities compared to the velocity distribution associated with a less negative net daily flow). The specifics of how net daily flow relates to the underlying velocity distribution depends on location in the Delta, local channel geometry, and the associated stage discharge relationship. For example, the same increase in net flow will be associated with a smaller change in the underlying velocity distribution on the larger-channel

mainstem San Joaquin River compared to the smaller-channel Old River. In another example, a location in the western Delta (with high tidal influence) and a location farther upstream (with less tidal influence) could have the same net flow but very different magnitudes of positive and negative velocities. At a given location, NMFS considers a change in net daily flow a useful proxy measure for qualitative, directional changes in the underlying velocity distribution. Specific to OMR, OMR flow represents a net daily flow that is a composite measure from two gauges in Old River and Middle River downstream of the export facilities near Bacon Island, and is estimated for real-time operations management using a calculated OMR Index.

Reclamation's 2023 BA provided data on both net flows (OMR flow) and the zone of influence from exports under CVP and SWP diversions which were generated from velocity distributions under the modeling scenario representing the two phases of the proposed action (ALT2v1 and Alt2v2), the No Action Alternative, and EXP3. Throughout this effects section, when NMFS refers to the effects of net OMR flow, NMFS is using it as a proxy for the underlying hydrodynamic conditions that mechanistically link to salmonid behavior and survival within the zone of influence. These lines of evidence inform our understanding of effects, both in terms of vulnerability to near-field project-related effects (entrainment to the export facilities) and far-field project-related effects (such as potential migratory disruptions at junctions or in channels). Buchanan and Skalski (2020) note that the overall volume of flow (measured as the root mean square of flow) at locations in the OMR corridor was a better predictor of survival than some net measures of flow in the OMR corridor, but the BA does not provide an analysis of that hydrodynamic metric. Additionally, it is not clear whether and how the CVP and SWP could manage exports to operate to a "direction-less" measure of South Delta hydrodynamics such as root mean square flow in the OMR corridor.

7.5.1.1.3. Entrainment Into Water Export Facilities

Once a fish is entrained into the CVP or SWP export facility, higher export rates may improve salvage efficiency. However, higher exports likely also increase overall entrainment and modify hydrodynamic conditions outside of the fish salvage facilities. The SWP has very poor salvage rates compared to the CVP.

Effects of exports outside the facilities diminish with distance, such that net daily flows in the South Delta are expected to be more negative (or less positive) between the export facilities and the OMR gauge locations and less negative (or more positive) northward of the OMR gauge locations. A change in OMR flow is expected to be associated with changes (in the same direction, but not necessarily magnitude) in net flows and underlying velocity distributions across the export zone of influence. Because exports can affect the flow split at the Head of Old River at a given Vernalis flow, export rates (particularly at low Vernalis flows) can affect flows in the mainstem San Joaquin River immediately downstream of the Head of Old River junction. For this reason, OMR changes due to export changes (especially at low, steady, Vernalis flows) can also be used as an indirect proxy for potential changes to mainstem San Joaquin River flows—not because of the observed flows in Old River and Middle River, but because the OMR metric is a proxy for export change if Vernalis flows are relatively steady. Likewise, if exports are steady, the OMR metric is a proxy for Vernalis flow change and associated changes in flow on the mainstem San Joaquin River.

Appendix I_Attachment X - "Delta Export OMR Zone of Influence Analysis" of Reclamation's BA (U.S. Bureau of Reclamation 2023-2024) provides a means to estimate the spatial extent of

the effects exports have on channel velocities for a range of inflow conditions and OMR flows. The "zone of influence" figures shown for the Delta for the December–June period summarize the overlap of velocity distributions under two paired scenarios. Figure 113 shows the spatial extent of export effects under phase 1 of the proposed action (with some foregone Delta exports pre-adoption of the VAs), while Figure 114 shows the spatial extent of export effects under phase 2 of the proposed action (without any Delta VA elements).

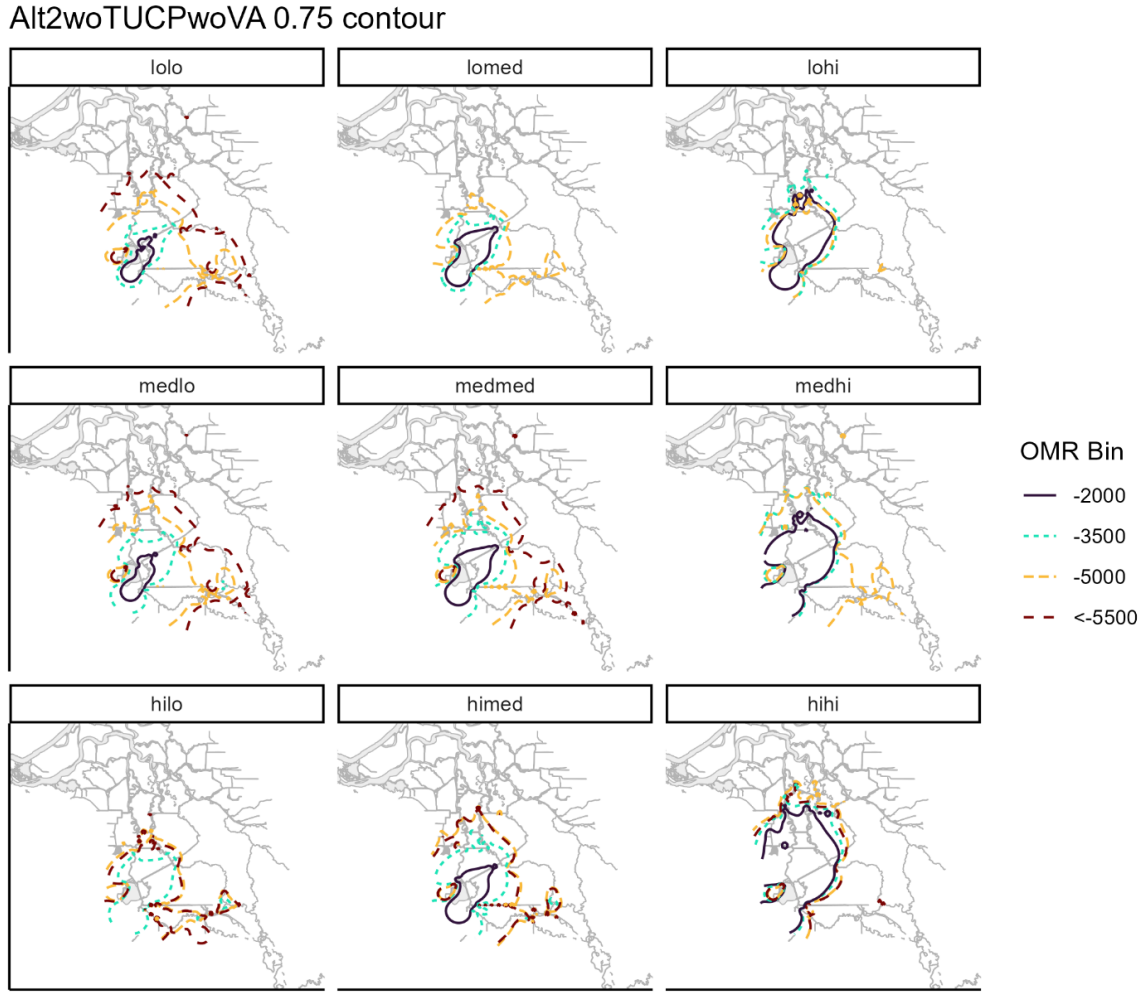


Figure 114. Faceted contour maps delineating Delta Export Zone of Influence under varying inflows and Old and Middle River (OMR) Flows under phase 2 of the proposed action (Alt2woTUCPwoVA [Alt2v1]).

The contours identify where there is up to 75% overlap in velocity distribution with and without CVP exports. Inflow groups are labeled with the relative flow range in the Sacramento River followed by the relative flow range in the San Joaquin River. The panels in the first, second, and third rows represent low, medium, and high Sacramento River flows. The panels in the first, second, and third columns represent low, medium, and high San Joaquin River flow. Results apply to Alt2v1.

Source: Figure 8 in Appendix I_Attachment X - Delta Export OMR Zone of Influence Analysis.pdf in (U.S. Bureau of Reclamation 2023-2024)

Overlaps of less than 75 percent are shown for different OMR values where the hydrodynamic changes of the proposed action (relative to the proposed action without exports) are centered in the southernmost Delta near the export facilities and in the OMR corridor. For a given inflow condition the "zone of influence" extends outward with decreasing (more negative) OMR values. Also, as expected, OMR changes appear less influential (tighter groupings of "zones") at higher inflows to the Delta, particularly with increasing San Joaquin River inflow. A key assumption is that while the study hypothesizes that lower proportional overlap values (less than 75 percent overlap) reflect higher alteration from pumping which would lead to higher likelihood of altering fish movements, the proportional overlap values do not reflect the magnitude of velocity differences, only that there were differences. Thus, two locations with the same value of proportional overlap (i.e., found along the same contour line for a given OMR value) may experience very different magnitudes of velocity difference. These figures also do not directly reflect biological implications, as velocity differences are not being analyzed, however, NMFS uses these results to inform our understanding of the spatial extent of project-related velocity changes that may alter fish movements.

7.5.1.1.4. Delta Survival

Several studies conducted on salmonid migration through the Sacramento-San Joaquin Delta provide an understanding of how Delta inflow affects juvenile salmonid survival (Newman 2003, Perry et al. 2010, Perry et al. 2013). These studies help to define the relationship of Sacramento River flow (at Freeport) and the survival of juvenile salmon through the Delta, as well as the importance that fish migration routing has on migratory success. The acoustic tag studies (Perry et al. 2010, Perry et al. 2015, Perry et al. 2018) indicate that survival probability increases with increasing flows, and changes in survival are steepest when flows are below 30,000 cfs at Freeport. The flow-survival relationship is strongest at lower flows and in the reaches that transition from riverine to tidal influence. The relationship between flow and survival conforms to the assumptions and results of the velocity and entrainment analyses that indicated low, slack, and reverse velocities increase entrainment risk and travel time, which reduce survival probabilities. For example, entrainment into the interior Delta via Georgiana Slough or Delta Cross Channel is increased when flows in the mainstem Sacramento River are low, reversing, or stagnant, and the proportion of fish remaining in the Sacramento River or entering Sutter or Steamboat Slough increase under high inflows (Perry et al. 2018). While the mechanisms causing reduced survival probabilities are likely combinations of reduced velocities, route selection, and increased entrainment into the interior Delta, the flow-survival relationship can be used to collectively evaluate the effects of flow changes on through-Delta survival.

The BA provided multiple lines of evidence that compared survival between modeling scenarios; the results are summarized by model in the Delta Effects Lines of Evidence section.

7.5.1.2. Presence of the Species Within the Bay-Delta Division

The approach used for this analysis was to identify which ESA-listed species would likely be present in the Bay-Delta Division and exposed to the proposed action-related stressors. NMFS relies on nearby CDFW and USFWS monitoring locations, run timing, and fish salvage data to

determine the likelihood of ESA-listed fish presence (Table 111). Adult salmonids typically migrate through the Delta within a few days. Juvenile Chinook salmon spend from 3 days to 3 months rearing and migrating through the Delta to the mouth of San Francisco Bay (Brandes and McLain 2001, MacFarlane and Norton 2002). Steelhead smolts have varied behaviors in their use of the Delta. Juvenile hatchery steelhead used in studies in the San Joaquin River and southern Delta had longer transit times to Chipps Island than juvenile Chinook salmon released in the same location on the Lower San Joaquin River. In contrast, Chapman et al. (2015), found that steelhead smolts rapidly moved through the San Francisco estuary system and entered the Pacific Ocean at the Golden Gate within days of entering the upper estuary (Suisun Bay). Some individual sDPS green sturgeon may move through the Delta region quickly from either upstream locations or from the estuary during their migratory behaviors, while others may spend a protracted amount of time within the Delta ranging from days to years while holding or rearing.

Table 111. Summary of temporal presence or absence of the NMFS-listed species in the Delta.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult SR	M	H	H	H	M	M	N	N	N	N	N	N
Juvenile SR	L	L	L	H	M	N	N	N	N	N	N	L
Salvaged SR	L	L	M	H	M	N	N	N	N	N	N	N
Adult WR	M	H	H	H	M	M	N	N	N	N	M	M
Juvenile WR	L	M	H	M	N	N	N	N	N	L	L	M
Salvaged WR	M	H	H	L	L	L	N	N	N	N	N	L
Adult SH	M	M	M	M	H	N	N	M	H	M	M	M
Juvenile SH	L	M	M	H	H	L	L	N	L	N	N	L
Salvaged SH	M	H	H	M	L	L	N	N	N	N	L	L
Adult GS	M	M	M	M	M	M	M	M	M	M	M	M
Juvenile GS	M	M	M	M	M	M	M	M	M	M	M	M
Salvaged GS	L	L	L	L	L	N	M	H	L	L	L	L

H = high presence (>25%, dark shading); M = medium presence (10–25%, medium-dark shading); L = low presence (1–10%, light shading); N = no presence (<1%, no shading).

SR = Central Valley spring-run Chinook salmon, WR = Sacramento River winter-run Chinook salmon, SH = California Central Valley steelhead, and GS = southern Distinct Population Segment of green sturgeon.

The solid red line indicates the in-water work window (July 1–October 31), with precautions for California Central Valley steelhead and the southern Distinct Population Segment of green sturgeon throughout the year.

Sources: Adult salmonids: (Hallock et al. 1961, Hallock and Fisher 1985, Vogel and Marine 1991, California Department of Fish and Game 1998, Yoshiyama et al. 1998, Moyle 2002, Lindley et al. 2004).

Juvenile Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and California Central Valley steelhead: (U.S. Fish and Wildlife Service 2014, 2015b, 2016a, 2017a, 2019) Delta Juvenile Fish Monitoring Program data USFWS 2011–2021.

Adult southern Distinct Population Segment of green sturgeon report cards: (California Department of Fish and Wildlife 2013, 2014a, 2015, 2016a, 2017, DuBois and Danos 2018) CDFG 2008–2012, CDFW 2013–2021.

Juvenile southern Distinct Population Segment of green sturgeon: (California Department of Fish and Wildlife 2021).

The Bay-Delta waterways function primarily as migratory corridors for SR winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon, but they also provide some use as holding and rearing habitat for each of these species as well. Juvenile salmonids may use the area for rearing for several months during the winter and spring before

migrating to the marine environment. The sDPS of green sturgeon use the area for rearing and migration year-round. Generally, as flows increase in the fall and through the winter, adult Chinook salmon, CCV steelhead, and sDPS green sturgeon migrate upstream through the Sacramento and San Joaquin rivers and juveniles migrate downstream in the winter and spring. Adult SR winter-run Chinook salmon typically migrate through the estuary/Delta from November to June with the peak occurring in March. Adult CV spring-run Chinook salmon migrate through the Delta from January to June, with a peak presence from February to April. Adult CCV steelhead migration into the Sacramento River watershed typically begins in August, with a peak in September and October, and extends through the winter to as late as May. Adult sDPS green sturgeon start to migrate upstream to spawning reaches in February and their migrations can extend into July, but may also be found holding in waters of the Sacramento River basin and Delta year-round.

7.5.1.2.1. Sacramento River Winter-Run Chinook Salmon

Adult SR winter-run Chinook salmon are expected to be in the Bay-Delta region from November through June with a peak presence from February to April as they migrate upstream to spawn in the Upper Sacramento River. Since the Delta is a transition zone between tidal and riverine sections of the Sacramento River, adult salmon sometimes wander through the Delta searching for specific olfactory cues that lead them to their natal spawning area. Adult SR winter-run Chinook salmon have been known to stray into the Sacramento Ship Channel and around the Delta islands and sloughs as they make their way through the maze of channels leading to the mainstem Sacramento River upstream of the Delta, including the Yolo Bypass when inundated.

For juvenile SR winter-run Chinook salmon, a review of Delta fish monitoring data from 2011 to 2021 showed very low numbers present from July through October (Table 111). The data show that juvenile SR winter-run Chinook salmon occur in the Delta primarily from November through April, with a peak occurrence in March, based on the length-at-date (LAD) criteria from trawl data in the Sacramento River near Sherwood Harbor (Figure 115) and trawl data at Chipps Island in the western Delta (Figure 116).

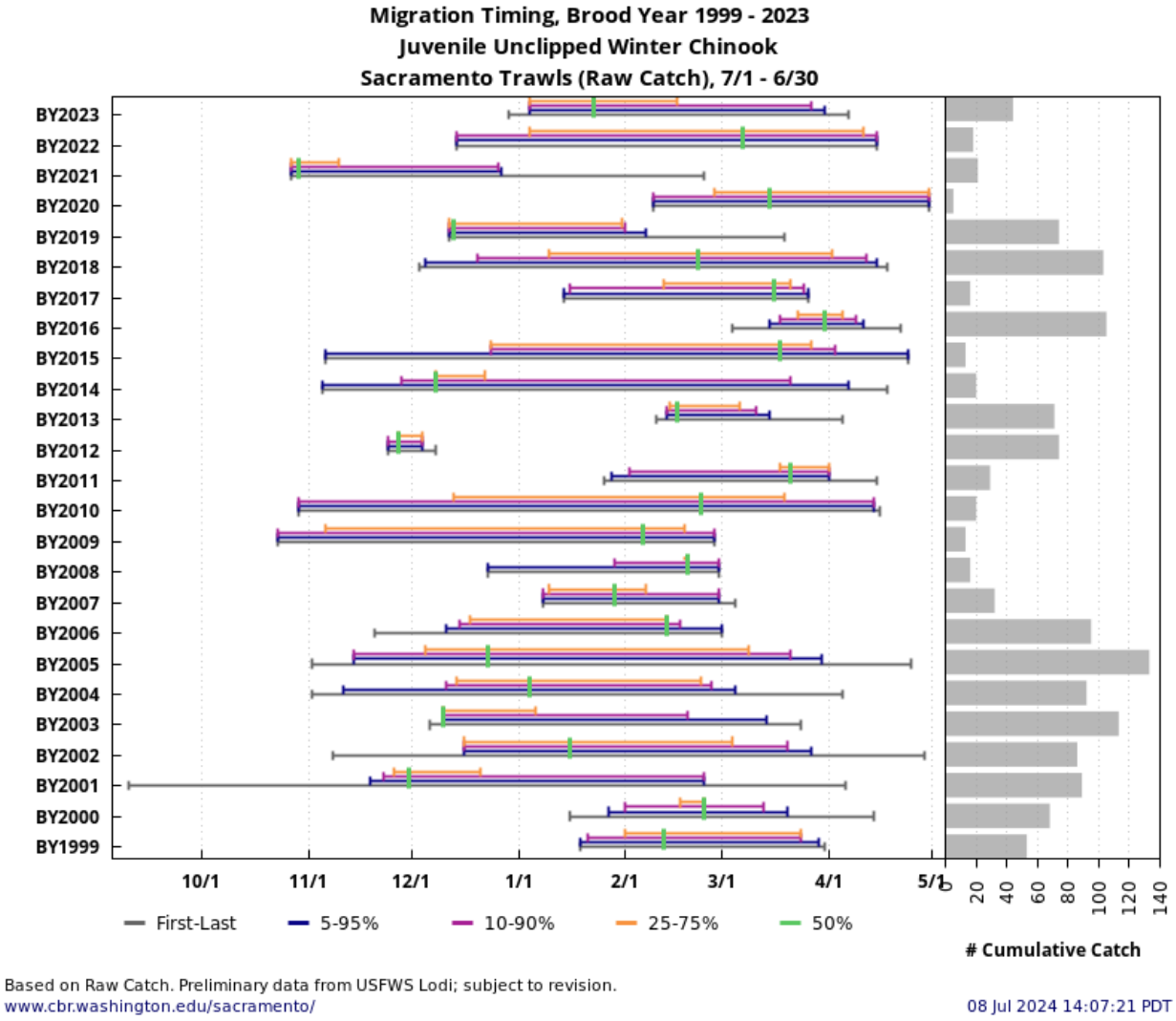


Figure 115. Juvenile Sacramento River winter-run Chinook salmon migration timing past the Sherwood Harbor-Sacramento Trawl location for brood years 1999 to 2023.

Source: SacPAS (University of Washington Columbia Basin Research 2024a)

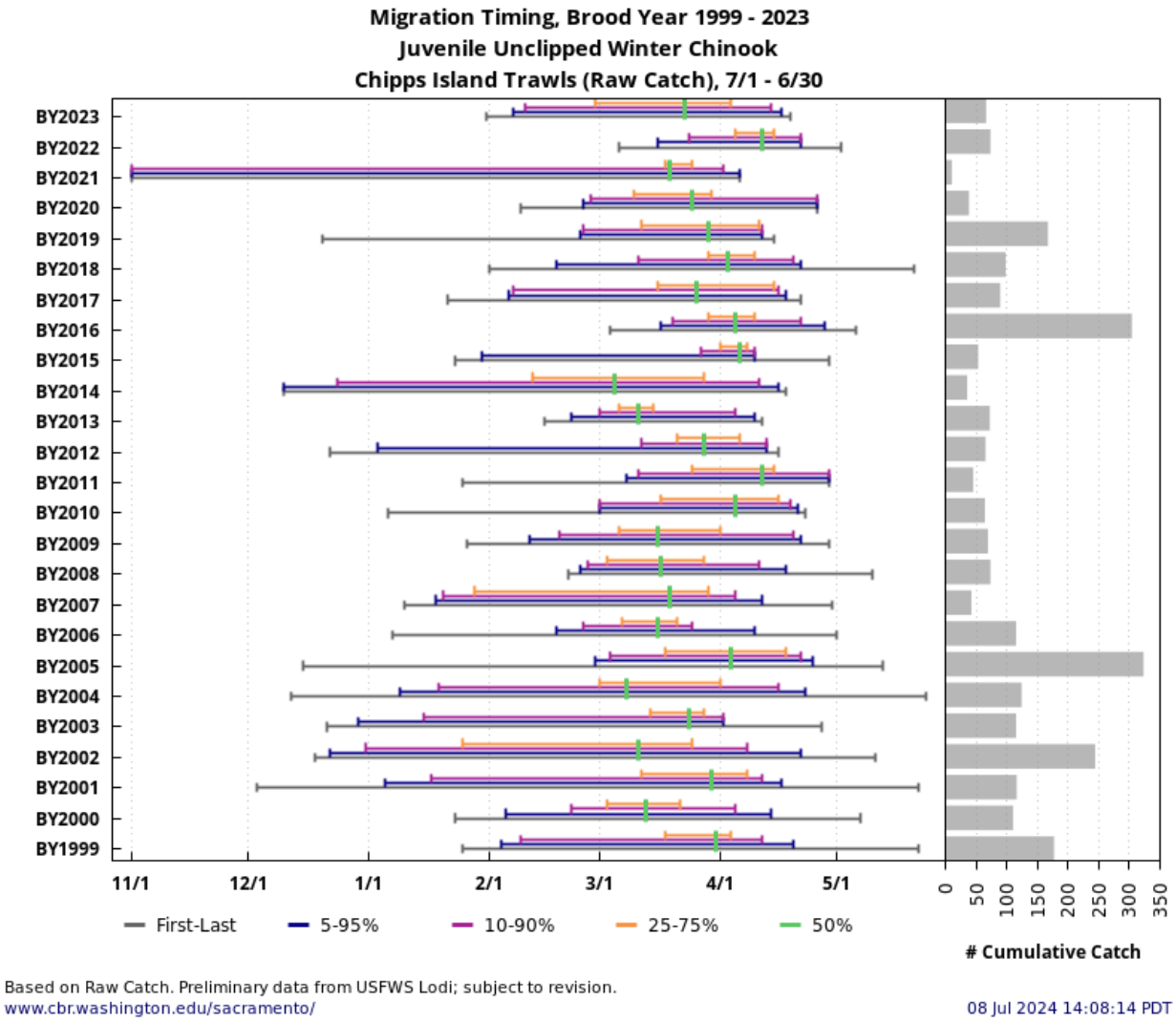


Figure 116. Juvenile Sacramento River winter-run Chinook salmon migration timing past the Chipps Island Trawl location for brood years 1999 to 2023.

Source: SacPAS (University of Washington Columbia Basin Research 2024a)

There are no reported populations of SR winter-run Chinook salmon that spawn in the San Joaquin River basin. Presence of adults is unlikely in the channels of the Delta south of the main stem of the San Joaquin River. Adults may stray into the channels of the Central Delta north of the mainstem San Joaquin River as they try to regain access to the mainstem Sacramento River through one of the major distributaries (i.e., Georgiana Slough and portions of the Lower Mokelumne River system).

Based on acoustic telemetry studies using late fall-run hatchery Chinook salmon (Perry et al. 2010, Perry et al. 2012, Perry et al. 2013, Romine et al. 2013), substantial fractions of the emigrating juvenile SR winter-run Chinook salmon population are expected to take alternate routes through the Delta, in addition to the mainstem Sacramento River route. In the North Delta, emigrating salmon are expected to utilize Sutter and Steamboat sloughs and the mainstem Sacramento River to reach the Western Delta. In addition, alternate routes through the Delta

interior are possible through Georgiana Slough and, when the radial gates are open, the Mokelumne River system via the Delta Cross Channel. These interior Delta waterways will route fish to the San Joaquin River mainstem via the terminus of the Mokelumne River. During the period when juvenile SR winter-run Chinook salmon move through alternate routes, they may utilize the Delta for rearing. A study by del Rosario et al. (2013) found that SR winter-run Chinook salmon are present in the Delta for an extended period of time, with an apparent residence time ranging from 41 to 117 days, with longer apparent residence times for juveniles arriving earlier at Knights Landing. Individual fish present in the mainstem San Joaquin River are subject to tidal forcing and may move into the channels of OMR, as well as other channel junctions in this reach, rather than moving towards the Western Delta. Juvenile SR winter-run Chinook salmon from the Sacramento River basin have been observed in salvage at the Tracy Fish Collection Facility and Skinner Delta Fish Protective Facility in the South Delta, indicating that juvenile SR winter-run Chinook salmon have the potential to be present in the waterways leading to these facilities. Due to extensive tidal movement and the creation of reverse flows in the two main channels (OMR) leading to the export facilities due to the diversion of water at these facilities, juvenile SR winter-run Chinook salmon may disperse into many of the waterways adjacent to the export facilities, including those waterways that contain the three South Delta agricultural barriers.

There are no spawning areas in the Bay-Delta region that could be used by adult SR winter-run Chinook salmon, therefore, the potential that eggs would be present in the Bay-Delta region is nonexistent. Likewise, the potential for alevins/yolk sac fry to be present in the Bay-Delta region is also unlikely due to the distance of the spawning reaches in the Upper Sacramento River locations from the Delta. Although it is infrequent, heavy precipitation events in the upper river watersheds adjacent to the spawning reaches of the Sacramento River could create high river flow conditions that stimulate fry and parr to migrate downstream to the Delta after emergence in the late summer and early fall, although precipitation events of this magnitude are more likely to occur later in the rainy season. Studies by Miller et al. (2010) and Sturrock et al. (2015) have shown that for CV fall-run Chinook salmon, sizeable fractions of the adult escapement is made up of fish that left freshwater and entered the marine environment as fry or parr life stages, along with the typical smolt life stage that is expected. Miller et al. (2010) found that among the parr and fry life stages leaving the freshwater environment, a large fraction (25 percent of parr and 55 percent of fry migrants) spent time rearing in the brackish waters of the Bay-Delta region. A similar diversity of life history strategies may exist for SR winter-run Chinook salmon.

7.5.1.2.2. Central Valley Spring-Run Chinook Salmon

Adult CV spring-run Chinook salmon are expected to migrate upstream through the Bay-Delta region from January to June with a peak presence from February to April (Table 111). Like adult SR winter-run Chinook salmon, adult CV spring-run Chinook salmon could stray into the Sacramento Ship Channel or the network of sloughs and waterways surrounding the northern and central Delta islands during their upstream migration.

Juvenile CV spring-run Chinook salmon (young-of-the-year) are present in the Bay-Delta region as they migrate to the ocean in the spring. Yearling CV spring-run Chinook salmon are expected to enter the Delta in late fall and early winter (late November). Juvenile CV spring-run Chinook salmon are expected to be present in the northern Delta region from December to May with a peak presence in March and April (Figure 117 and Figure 118).

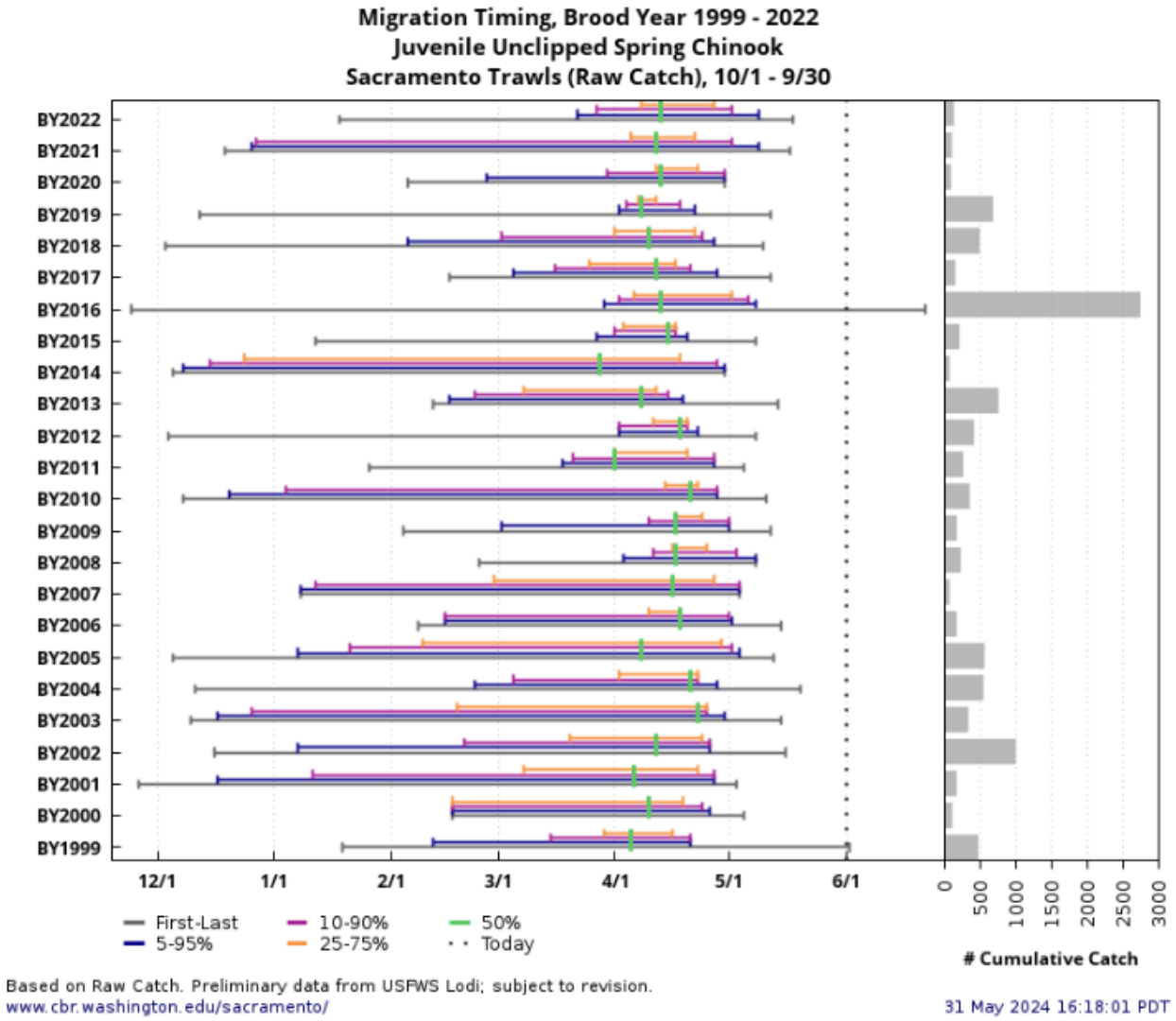


Figure 117. Juvenile Central Valley spring-run Chinook salmon migration timing past the Sherwood Harbor – Sacramento Trawl location for brood years 1999 to 2022.

Source: SacPAS (University of Washington Columbia Basin Research 2024a)

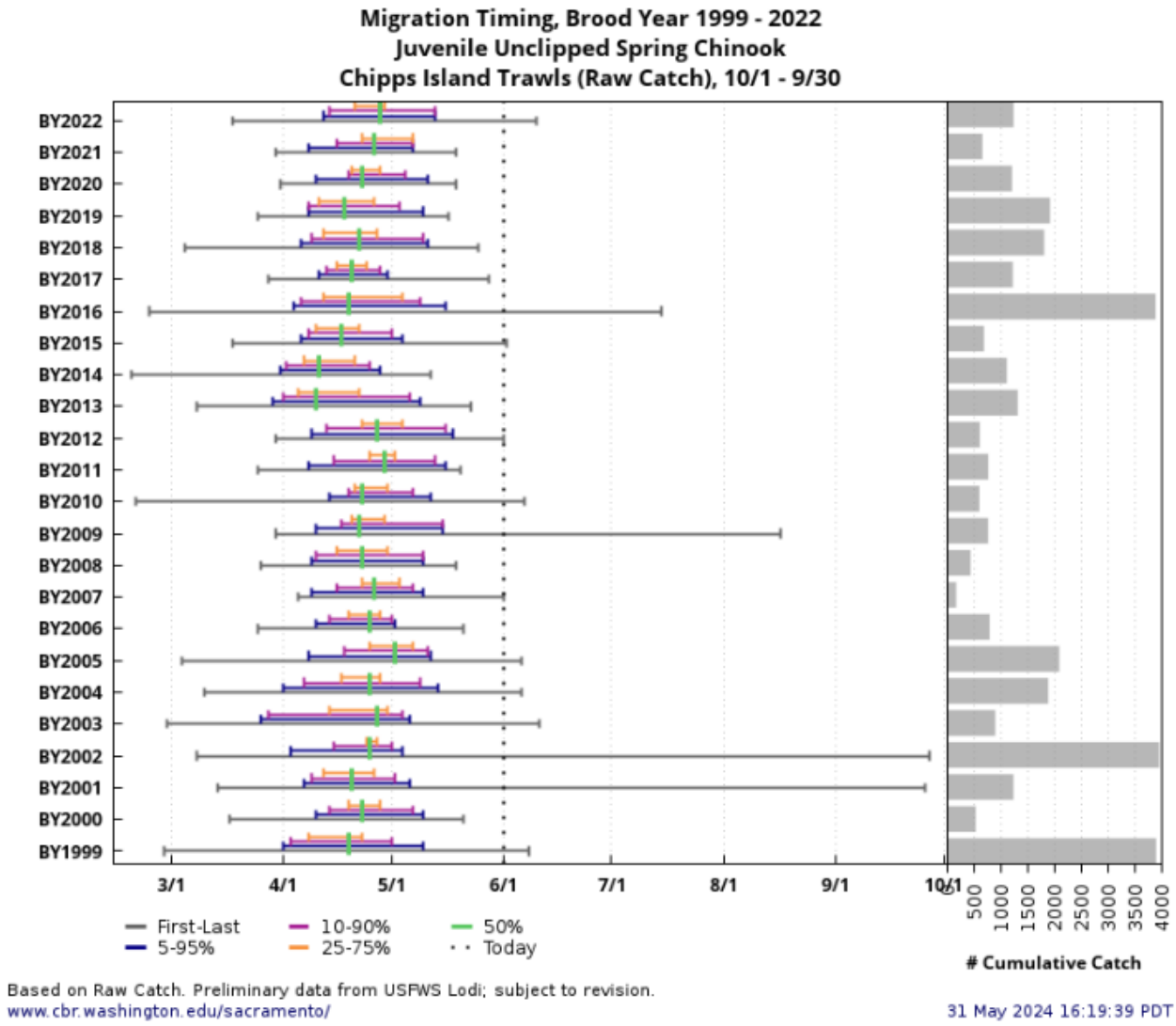


Figure 118. Juvenile Central Valley spring-run Chinook salmon migration timing past the Chipps Island Trawl location for brood years 1999 to 2022.

Source: SacPAS (University of Washington Columbia Basin Research 2024a)

There is evidence of CV spring-run Chinook salmon occurring in the Mokelumne, Stanislaus, Tuolumne, and Merced rivers. Those CV spring-run Chinook salmon who originate in these rivers will use the Delta as a migration corridor as juveniles, migrating to the ocean and during their adult, return migration (Franks 2013, National Marine Fisheries Service 2016a, Gutierrez et al. 2024). Furthermore, the SJRRP's reintroduction of a non-essential population of CV spring-run Chinook salmon in the San Joaquin River basin (78 FR 79622 2013) also results in the presence of CV spring-run Chinook salmon in the southern Delta and San Joaquin River regions of the Bay-Delta area over the lifetime of the proposed action. However, the juveniles released from the Salmon Conservation and Research Facility are 100-percent marked with an adipose-fin clip and CWT that identifies them as SJRRP individuals. NMFS issues an annual technical

memorandum to account for juvenile SJRRP fish that may show up at the CVP and SWP fish salvage facilities.[21]

There are no spawning areas in the Bay-Delta region that could be used by adult CV spring-run Chinook salmon; therefore, the potential that eggs would be present in this area is nonexistent. Likewise, the potential for alevins and yolk-sac fry to be present in the Bay-Delta region is also unlikely, since only extreme precipitation events in the fall and early winter resulting in high river flows in the Sacramento or San Joaquin river basins could flush alevins out of their natal tributaries into the Delta. Fry and parr are more likely to be present in the Delta region in response to high river flows due to the timing of winter storms and the progressive maturation of the fish. This period would be from approximately November through March. By April, juvenile CV spring-run Chinook salmon are reaching the size when smoltification occurs, and most smolts would be moving downriver to enter the Delta on their emigration to the ocean. Central Valley spring-run Chinook salmon smolt out-migration is essentially over by mid-May, with only a few late fish emigrating in early June. There is the potential that some juvenile CV spring-run Chinook salmon remain in the tributaries through the summer and out-migrate the following fall and winter as yearlings (Cordoleani et al. 2021). Adult CV spring-run Chinook salmon are expected to be migrating upstream through the Bay-Delta from January to June, with a peak presence from February to April. In both the Sacramento and San Joaquin river basins, adult CV spring-run Chinook salmon migrate into their natal rivers from approximately March through June.

7.5.1.2.3. California Central Valley Steelhead

The majority of CCV steelhead originate in the Sacramento River basin and its multiple tributaries and are composed of the Northern Sierra Nevada, Northwestern California, and Basalt and Porous Lava diversity groups. However, small, but persistent populations of CCV steelhead are present in the San Joaquin River basin tributaries and are part of the Southern Sierra Nevada Diversity Group. Both adults and smolts are detected by monitoring efforts in these basins, indicating spawning is occurring in the basins' tributaries (Eilers 2010)

Natural CCV steelhead juveniles (smolts) start to appear in the northern Bay-Delta region as early as October, based on the data from the Sacramento River and Chipps Island trawls (Speegle et al. 2013, Barnard et al. 2015, Miller et al. 2017, University of Washington Columbia Basin Research 2024a), Figure 119, Figure 120) and CVP and SWP fish salvage facilities (California Department of Fish and Wildlife 2018). Adult CCV steelhead begin to migrate through the northern portion of the Bay-Delta region (Lower Sacramento River) in July and continue through late fall, with a secondary peak occurring in late spring (presumably adults returning downstream as post spawn fish, or "kelts"). Most adult CCV steelhead migrate into the Sacramento River basin in late summer and fall on their upstream spawning run. The percentile of adult migration passage during this period is 2 percent for July, 12 percent for August, 44.5 percent for September, and 25 percent for October (Hallock et al. 1957, Hallock et al. 1961).

Adult CCV steelhead in the San Joaquin River basin are expected to start moving upstream through the southern portion of the Bay-Delta region into the Lower San Joaquin River as early as September, with the peak migration period occurring later in the fall during the November

[21] Annual technical memorandums are available at https://www.fisheries.noaa.gov/west-coast/habitat-conservation/san-joaquin-river-restoration.

through January period, based on Stanislaus River fish weir counts. Adult CCV steelhead continue to migrate upriver through March, with kelts moving downstream potentially through the spring and early summer, although most are expected to move back downstream earlier than later.

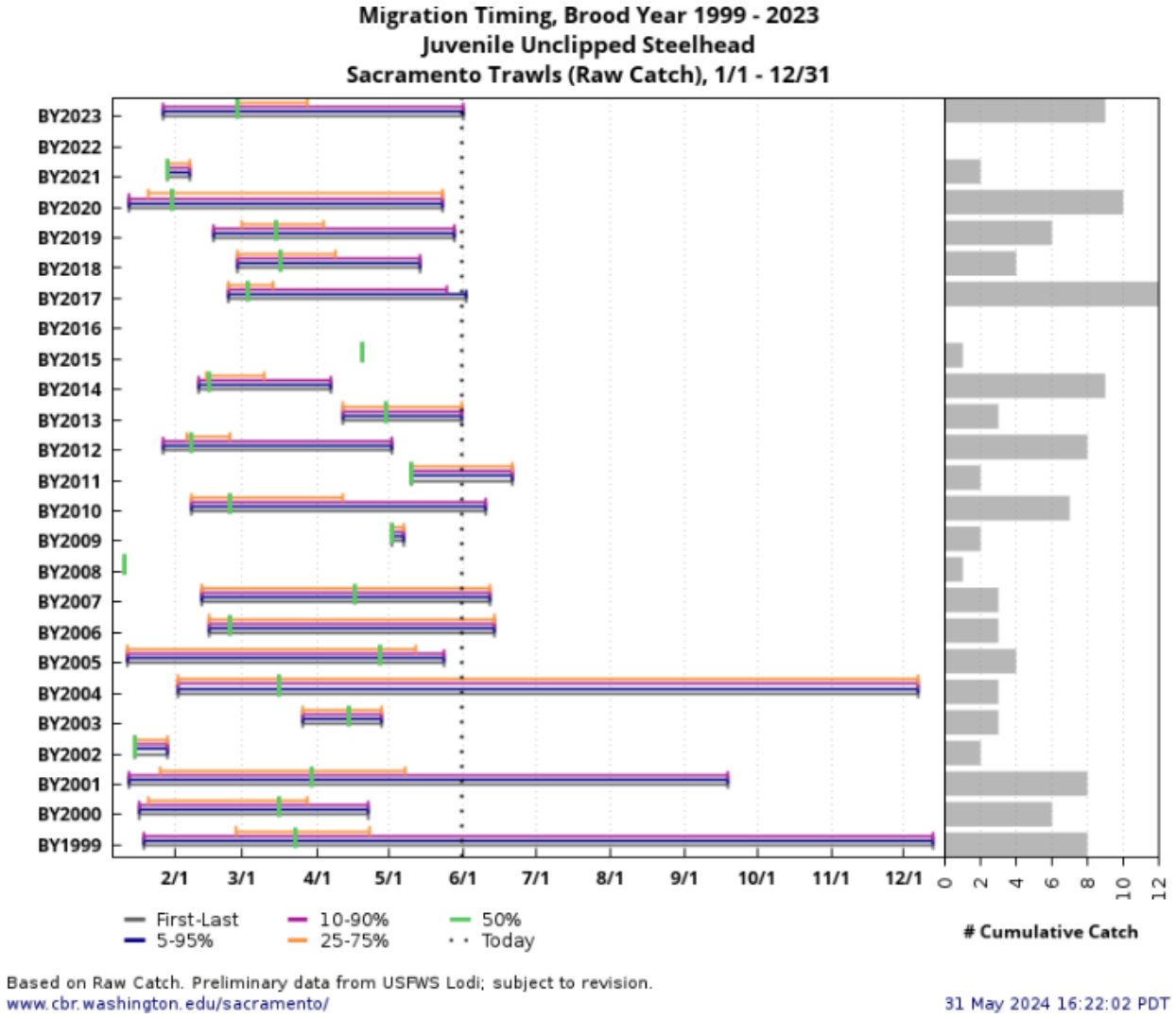


Figure 119. Juvenile unclipped California Central Valley steelhead migration timing past the Sherwood Harbor – Sacramento Trawl location for brood years 1999 to 2023.

Source: SacPAS (University of Washington Columbia Basin Research 2024a)

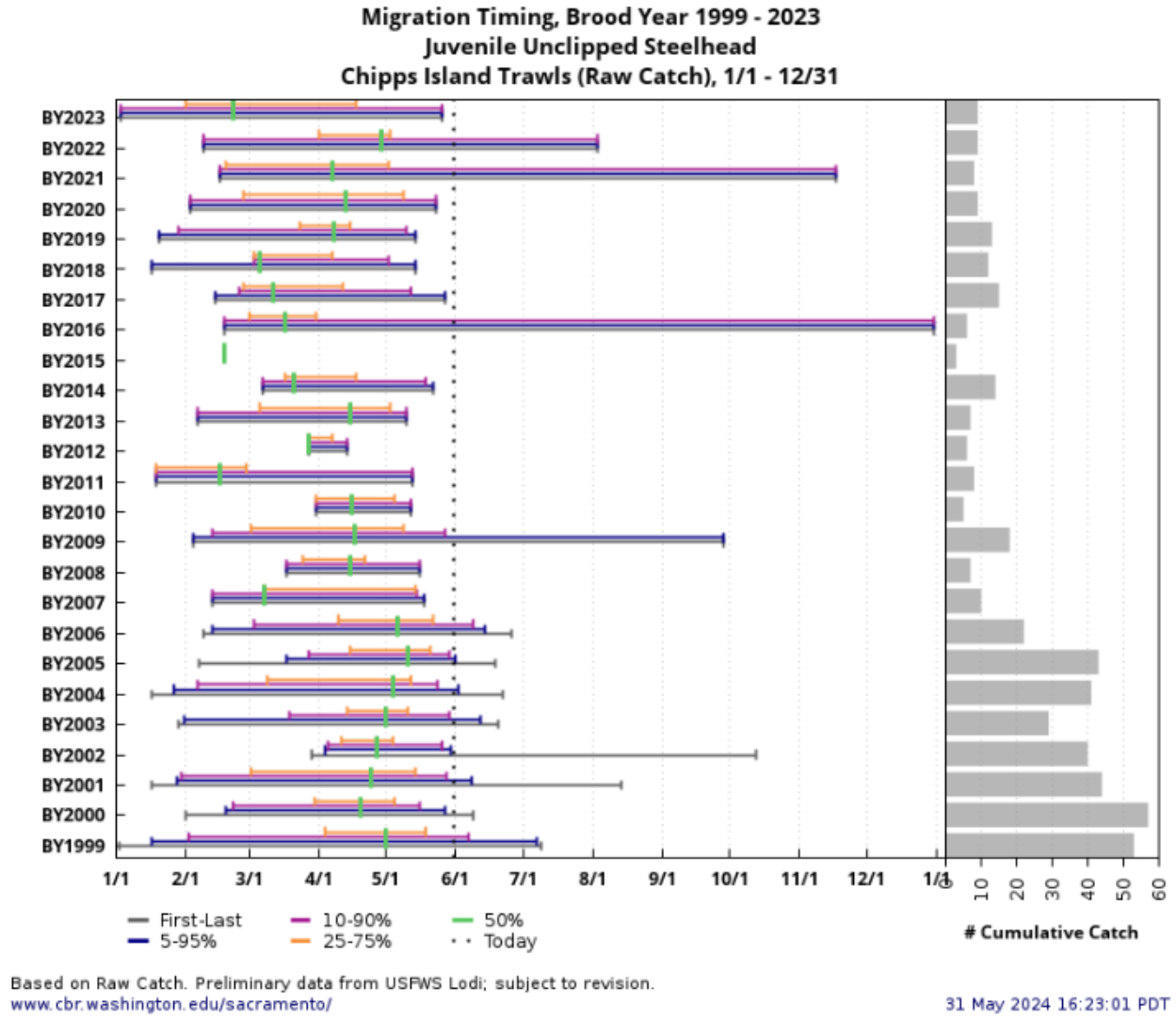


Figure 120. Juvenile unclipped California Central Valley steelhead migration timing past the Chipps Island Trawl location for brood years 1999 to 2023.

Source: SacPAS (University of Washington Columbia Basin Research 2024a)

In the Sacramento River, juvenile CCV steelhead generally migrate to the ocean from early winter to early summer at 1 to 3 years of age and 100 to 250 millimeters fork length, with peak migration through the Delta occurring in March and April (Reynolds et al. 1993). In the San Joaquin River basin, CCV steelhead smolts are expected to appear in the southern Bay-Delta regional waterways as early as January, based on observations in tributary monitoring studies on the Stanislaus River, but in very low numbers. The peak emigration in the Lower San Joaquin River, as determined by the Mossdale trawls near the Head of Old River, occurs from April to May, but with presence of fish typically extending from late February to late June.

Juvenile CCV steelhead presence in CVP and SWP fish salvage facilities increases from November through January (12.4 percent of average annual salvage) and peaks in February (40.4

percent) and March (26.9 percent) before rapidly declining in April (13.3 percent) and May (4.4 percent; (National Marine Fisheries Service 2016b). By June, emigration essentially ends, with only a small number of fish being salvaged through the summer at the CVP and SWP fish salvage facilities. Juvenile CCV steelhead detected at the salvage facilities may arise from either the Sacramento River watershed or from the San Joaquin River watershed. Based on the timing of CCV steelhead juveniles and smolts observed in monitoring programs, Sacramento River basin fish tend to enter the Delta earlier in the winter and spring than their counterparts in the San Joaquin River basin.

7.5.1.2.4. Southern Distinct Population Segment of Green Sturgeon

Adult sDPS green sturgeon begin to enter the Bay-Delta in late February and early March during the initiation of their upstream spawning run (Moyle et al. 1995, Heublein et al. 2009). The peak of adult entrance into the Delta appears to occur in late February through early April, with fish arriving upstream of the Glenn-Colusa Irrigation District's water diversion on the Upper Sacramento River in April and May to access known spawning areas (Moyle 2002). Adults continue to enter the Delta until early summer (June–July) as they move upriver to spawn in the Upper Sacramento River basin. It is also possible that some adult sDPS green sturgeon will be moving back downstream as early as April and May through the Bay-Delta region, either as early post-spawners or as unsuccessful spawners. Most post-spawn adult sDPS green sturgeon will move downriver to the Delta either in the summer or during the fall. Fish that over-summer in the Upper Sacramento River will move downstream when the river water cools and rain events increase the river's flow and either hold in the Delta or migrate directly to the ocean (Klimley et al. 2015). Data on sDPS green sturgeon distribution are extremely limited and out-migration appears to be variable, occurring at different times of year. Recreational fishing catch data for adult sDPS green sturgeon (California Department of Fish and Game 2009, 2010, 2011, 2012, California Department of Fish and Wildlife 2013, 2014a, 2015, 2016a, 2017, DuBois and Danos 2018) show that they are present in the Delta during all months of the year (Figure 121). Although the majority of sDPS green sturgeon are expected to be found along the Sacramento River corridor and within the western Delta, observations of sDPS green sturgeon occur in the San Joaquin River and upstream of the southern Delta region based on the information provided in the CDFW sturgeon fishing report cards. Presence of fish occurs during all seasons of the year, but primarily from fall through spring. Few fish are caught during the summer period.

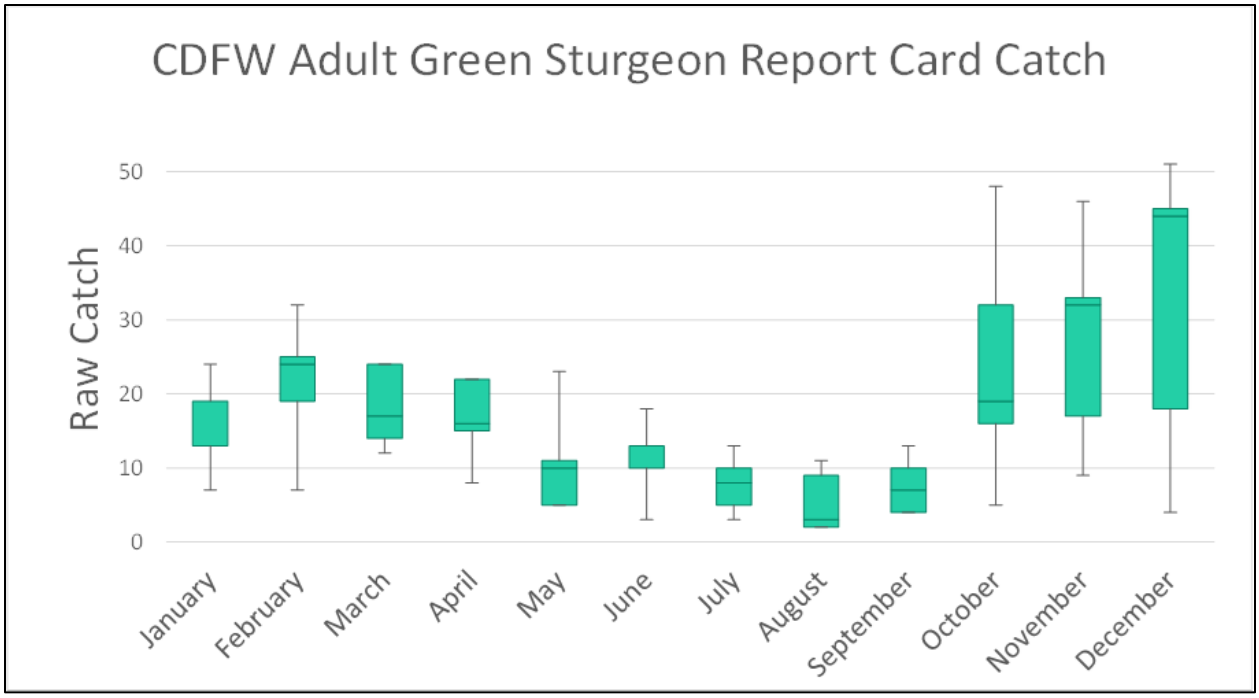


Figure 121. Adult raw catch data for the southern Distinct Population Segment of green sturgeon in the Delta from 2008 to 2021.

Juvenile sDPS green sturgeon migrate to the sea when they are 1 to 4 years old (Moyle et al. 1995). According to Radtke (1966), juveniles were collected year-round in the Delta during a 1-year study in 1963–1964. The Delta Juvenile Fish Monitoring Program rarely collected juvenile sDPS green sturgeon at the seine and trawl monitoring sites. From 1999 to 2023, 506 juvenile sDPS green sturgeon have been salvaged at the CVP and SWP fish salvage facilities (University of Washington Columbia Basin Research 2024a). Their timing appears to vary over the years, but they appear to have a higher presence during the spring and summer months in the South Delta where the export facilities are located (Figure 122).

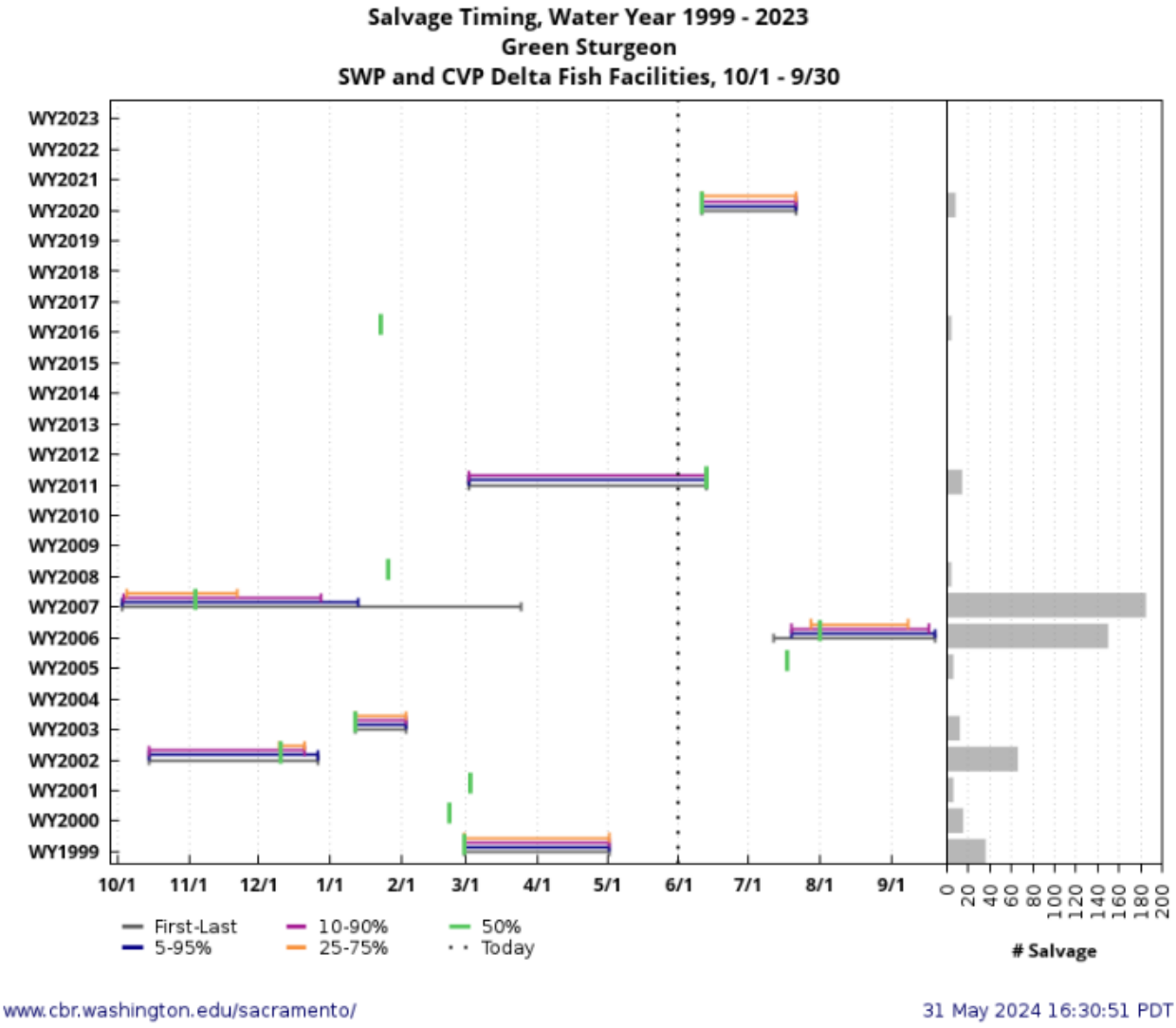


Figure 122. Juvenile green sturgeon salvage timing at the Central Valley Project (CVP) and State Water Project (SWP) fish facilities during water years 1999 to 2023.

Source: SacPAS (University of Washington Columbia Basin Research 2024a)

Based on the above information, adult and juvenile sDPS green sturgeon were determined to be present in the Delta year-round.

7.5.1.3. Delta Effects Lines of Evidence

7.5.1.3.1. Key CalSim 3 outputs

While in some cases individual proposed action elements can be linked to specific modeling outcomes, the effects of the proposed water operations to listed fish species in the Delta relate generally to hydrodynamic conditions affecting migration success and survival, which are the aggregate effect of the collection of proposed action elements in the Bay-Delta Division. The biggest CVP and SWP-related drivers of Delta hydrodynamics are inflow from the Sacramento River (Figure 123), inflow from the San Joaquin River (Figure 124), and combined CVP and SWP exports (Figure 125). NMFS acknowledges that inflows to the Delta are also affected by hydrology and runoff in addition to managed releases from upstream reservoirs. Two key measures of Delta hydrodynamic conditions are OMR flows (representing conditions in the South Delta and linked primarily to San Joaquin River inflow and Delta exports; Figure 126) and Delta outflow (measured in the western Delta but higher outflow is also representative of higher inflows and/or lower exports elsewhere in the Delta; Figure 127). Those three key inputs to and two key outputs of Delta hydrodynamics are described below for data averaged across all years in the CalSim 3 period of record, 1922–2021. Additional details on modeling results for these flow and export metrics, by month and water year type, are provided in Appendix F of Reclamation's BA (U.S. Bureau of Reclamation 2023-2024).

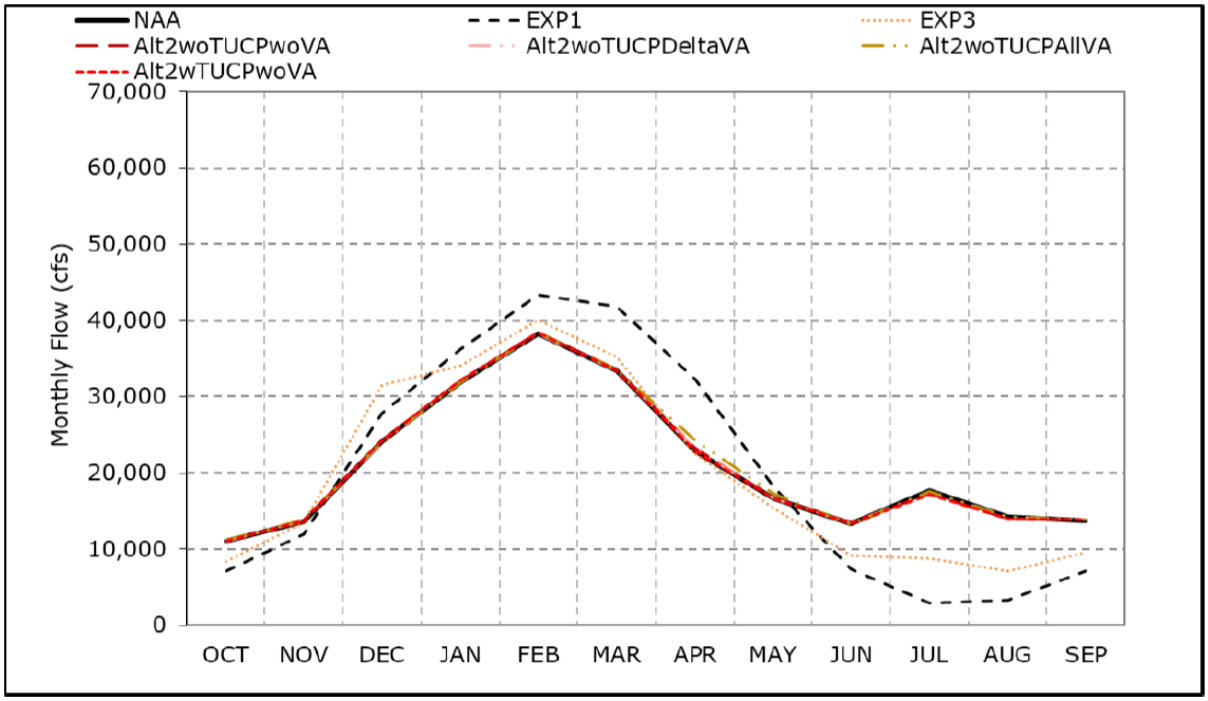
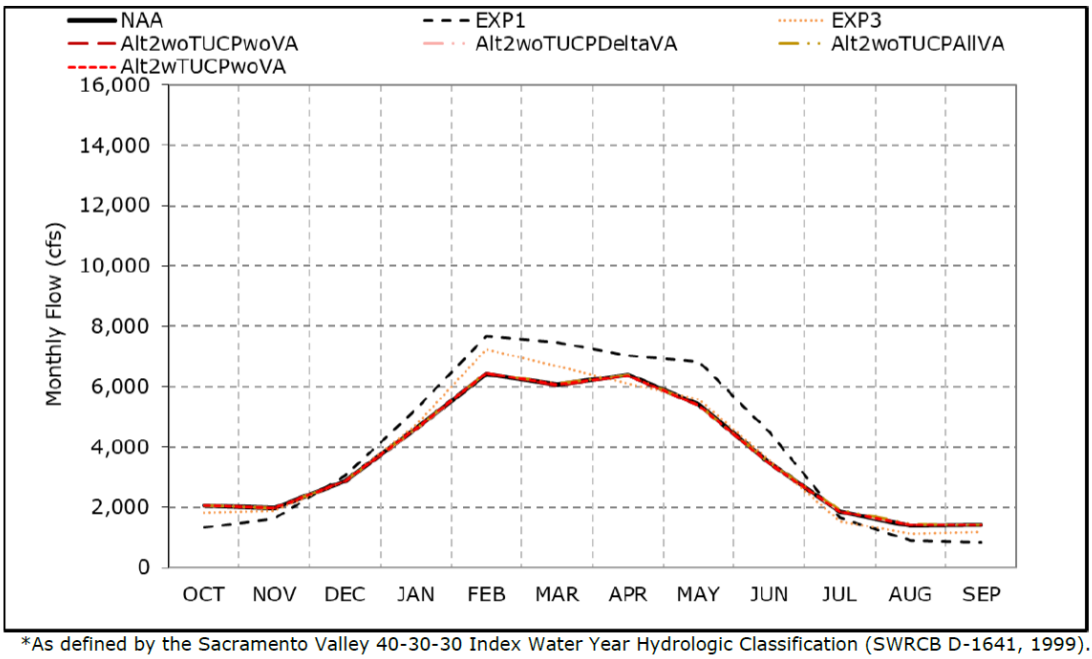


Figure 123. Modeled Freeport flow (cubic feet per second [cfs]) over all water year types.

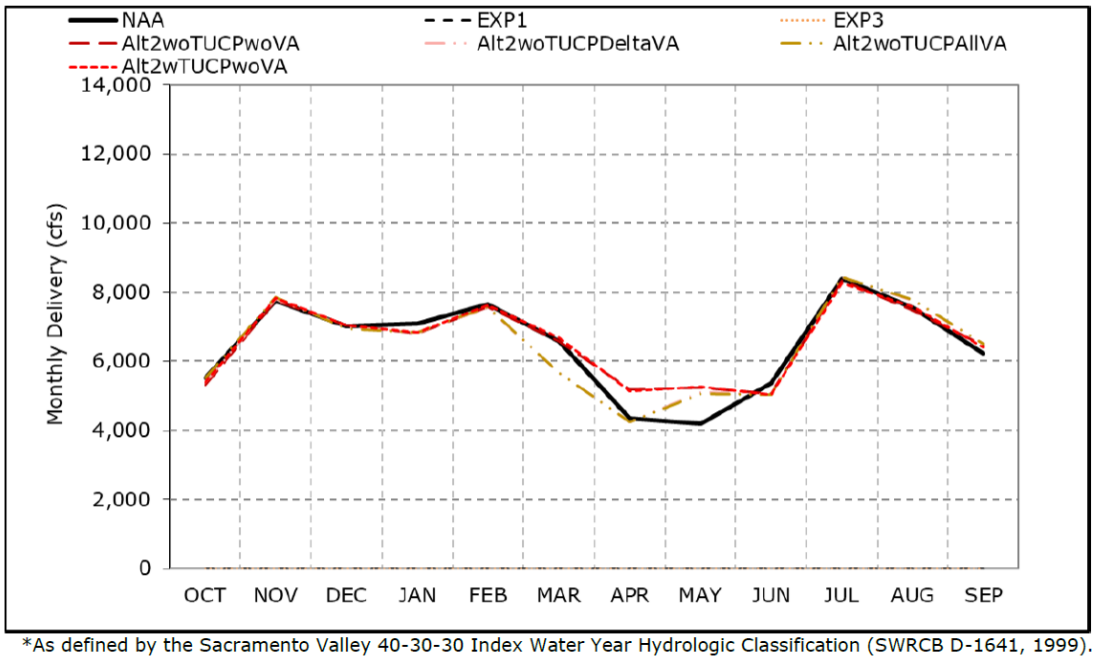
Source: (Figure F.2.2-14-1 from Appendix F, Attachment 2-2 in (U.S. Bureau of Reclamation 2023-2024)



*As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).
*Water Year Types results are displayed with calendar year – year type sorting.
*All scenarios are simulated at 2022 Median climate condition and 15 cm sea level rise.

Figure 124. Modeled Vernalis flow (cubic feet per second [cfs]) over all water year types.

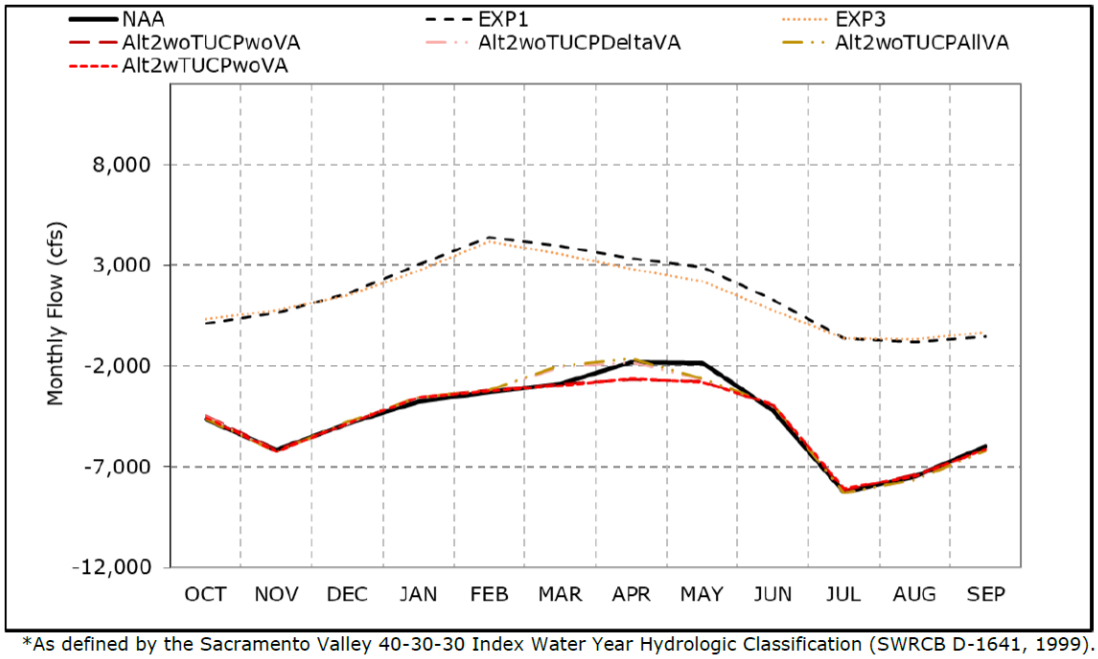
Source: Figure F.2.2-21-1 from Appendix F, Attachment 2-2 in (U.S. Bureau of Reclamation 2023-2024)



*As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).
*Water Year Types results are displayed with calendar year – year type sorting.
*All scenarios are simulated at 2022 Median climate condition and 15 cm sea level rise.

Figure 125. Modeled Total Delta exports (cubic feet per second [cfs]) over all water year types. Note that the EXP3 data series is 0 cfs in all months.

Source: Figure F.2.3-8-1 from Appendix F, Attachment 2-3 in (U.S. Bureau of Reclamation 2023-2024)



*As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).
*Water Year Types results are displayed with calendar year – year type sorting.
*All scenarios are simulated at 2022 Median climate condition and 15 cm sea level rise.

Figure 126. Modeled Old and Middle River flow (cubic feet per second [cfs]) over all water year types.

Source: Figure F.2.2-23-1 from Appendix F, Attachment 2-2 in (U.S. Bureau of Reclamation 2023-2024)

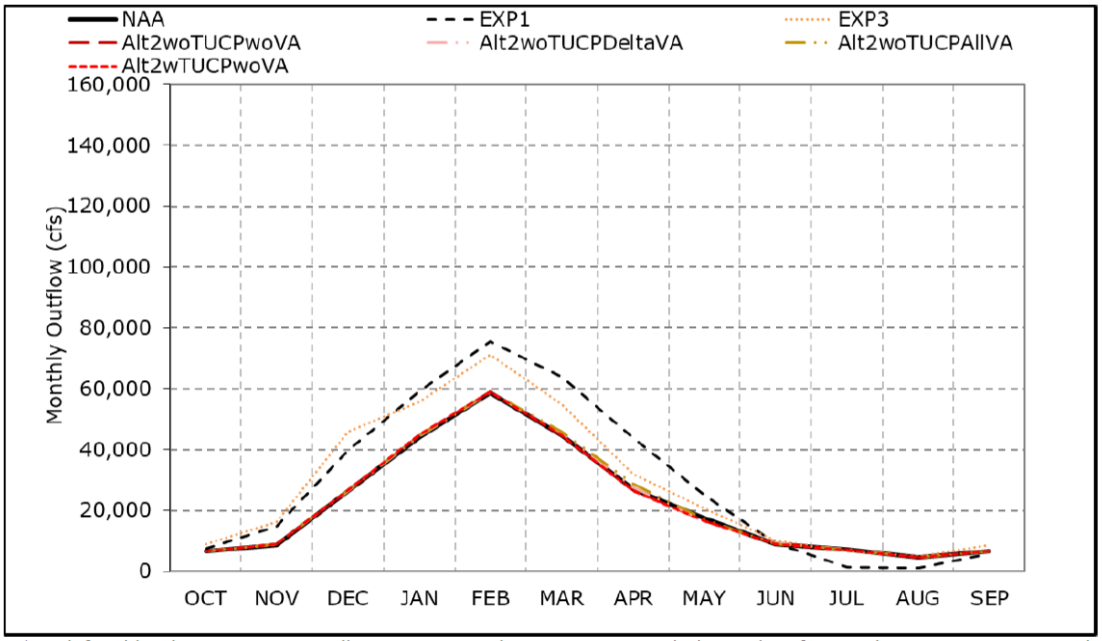


Figure 127. Modeled Delta outflow (cubic feet per second [cfs]) over all water year types.

Source: Figure F.2.2-24-1 from Appendix F, Attachment 2-2 in (U.S. Bureau of Reclamation 2023-2024)

7.5.1.3.2. Old and Middle River STARS model

As described at https://oceanview.pfeg.noaa.gov/shiny/FED/CalFishTrack/, the Survival Travel Time And Routing Simulation (STARS) model (Perry et al. 2018) "simulates travel time, routing, and survival of individuals in a daily cohort as they migrate through eight unique reaches of the Delta. A daily cohort is defined as all fish that enter the Delta on a given day at Freeport. Because travel time, routing, and survival depends on river flow when an individual enters a given reach, overall survival of a daily cohort depends on the entire time series of daily flows during their migration time through the Delta. For example, two cohorts may enter the Delta at the same discharge, but their overall survival will differ if one cohort enters during an ascending hydrograph and the other enters when it [is] descending." The implementation of the simulation model currently available for use is calibrated to acoustic-tagged late-fall-run Chinook salmon released from 2007 to 2011. Data inputs to the model for scenario analysis were obtained by assigning monthly CalSim output for Freeport flow to constant daily values within each month. Results are for individuals in cohorts or fish who enter the model's "system" daily at Freeport.

Because the STARS model is applied to fish entering the Delta at Freeport, results are most applicable to juvenile salmonids entering the Delta from the Sacramento River basin. The survival and routing in the model are based on Freeport flows and the status of the Delta Cross Channel gates. These modeling results are not sensitive to changes in project operations that

affect, for example, exports or OMR flows, though some apparent trends might appear to the extent that exports or OMR are correlated to Delta inflow at Freeport. For context in interpreting results, Freeport flows for the various scenarios are provided in Figure 128. As described in "Appendix F: Modeling – Section 1-2, Callouts Table" (U.S. Bureau of Reclamation 2023-2024), and summarized earlier in Table 107, assumed Delta Cross Channel gate operations are identical across scenarios for the months (December–April) modeled using STARS (Delta Cross Channel operations differ during October–November and the summer), so differences in survival during these months can be entirely attributed to variation in Freeport flows.

Figure F.2.2-14-1. Sacramento River Flow at Freeport, Long-Term Average Flow

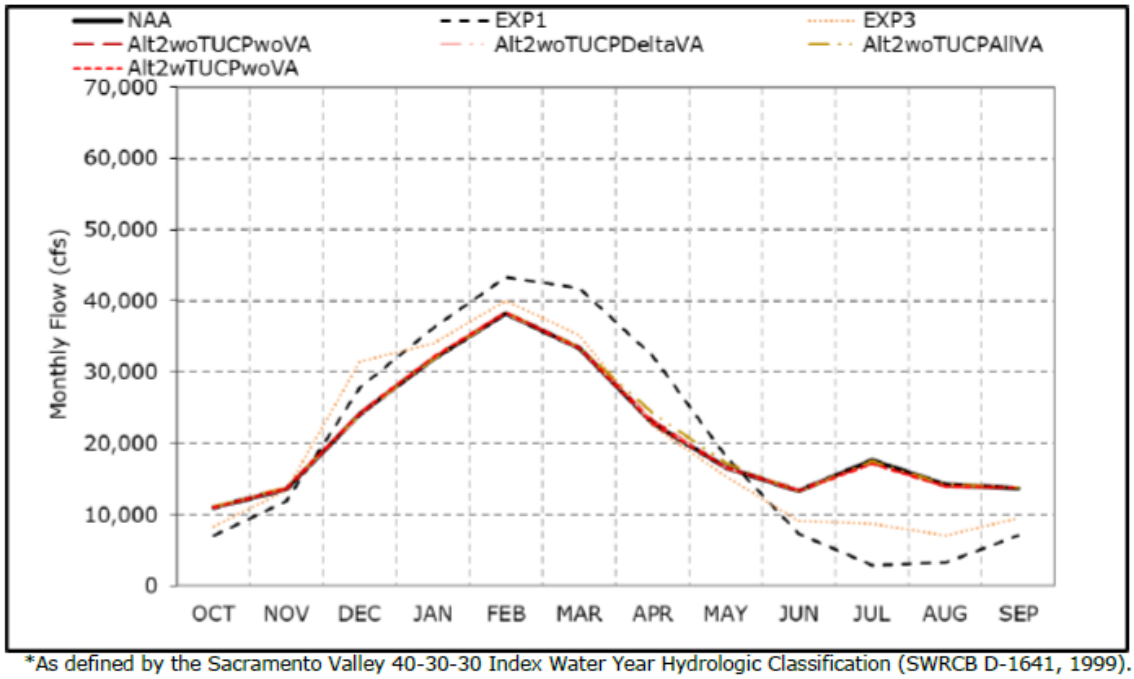


Figure 128. Freeport flow (cubic feet per second [cfs]) over all water year types.

Source: Figure F.2.2-14.1 from Appendix F, Attachment 2-2 in (U.S. Bureau of Reclamation 2023-2024)

Detailed results for interior Delta routing and through-Delta survival by water year type and inflow group are provided in the "OMR STARS Model" attachment to Appendix I of the BA (U.S. Bureau of Reclamation 2023-2024). Selected results are summarized below.

The proportion of fish entering the Delta at Freeport that route into the interior Delta through the Delta Cross Channel or Georgiana Slough is shown by month in Figure 129. Key patterns include:

- All scenarios show higher routing into the interior Delta during December and April compared to January, February, and March. In general, routing into the interior Delta increases as flow past the Delta Cross Channel and Georgiana Slough decreases, so the

routing result is consistent with the expectation based on the pattern of Freeport flows (Figure 128), which shows lower flows in December and April compared to January, February, and March.

- Within each month, the Alt2v1, Alt2v2, and NAA scenarios all show very similar levels of routing into the interior Delta, which is the expected result since the monthly patterns of Freeport flows (Figure 128) and Delta Cross Channel gate operations December-April (Table 107) for those three scenarios are very similar.
- Relative to the Alt2v1, Alt2v2, and NAA scenarios, the EXP3 results show a shift in median routing into the interior Delta, though there is still considerable overlap in the overall range of results. Specifically, median routing for the EXP3 scenario is noticeably lower in December, January, and March; similar in February; and higher in April. Again, this is consistent with expectations based on the patterns in Freeport flow. See, for example, that Freeport flow for the EXP3 scenario is higher in December (Figure 130), similar in February (Figure 131), and lower in April (Figure 132).

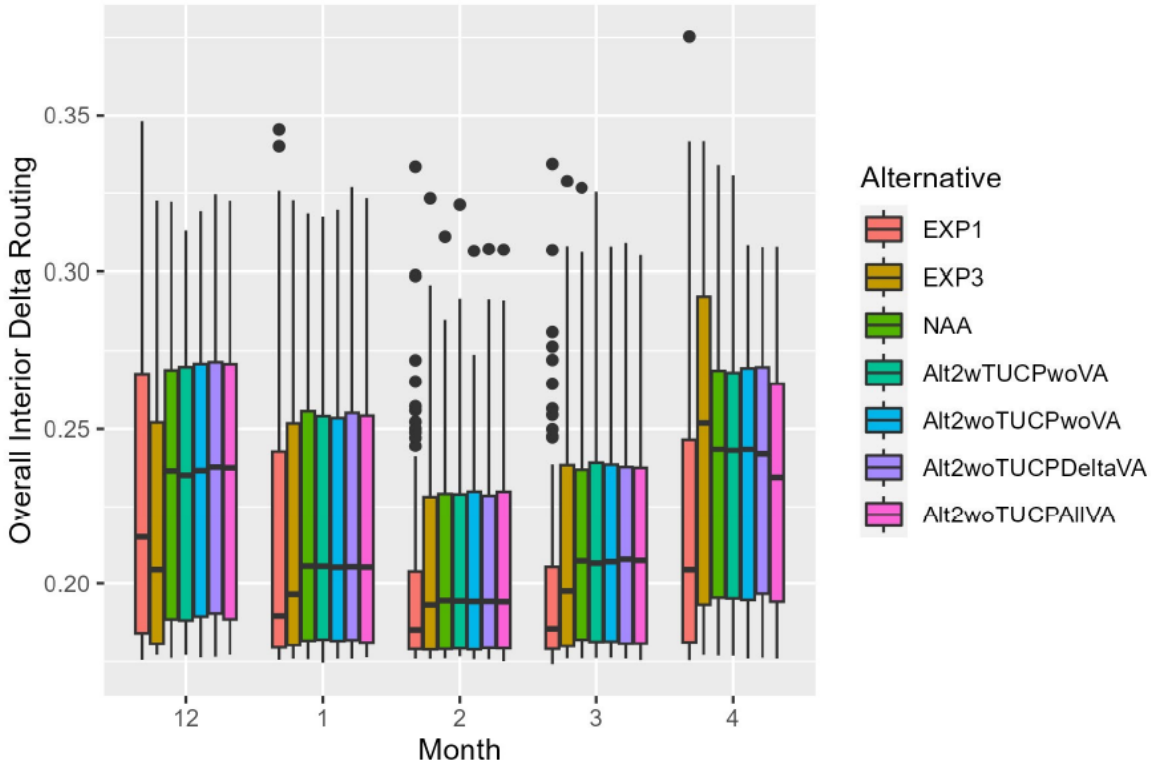


Figure 129. Boxplots of predicted routing proportions to the Interior Delta for relevant migratory months. The box edges represent 25th and 75th percentiles, and whiskers are the product of the interquartile range and 1.5.

Source: Figure 12 from Appendix I, Attachment X - STARS model in (U.S. Bureau of Reclamation 2023-2024)

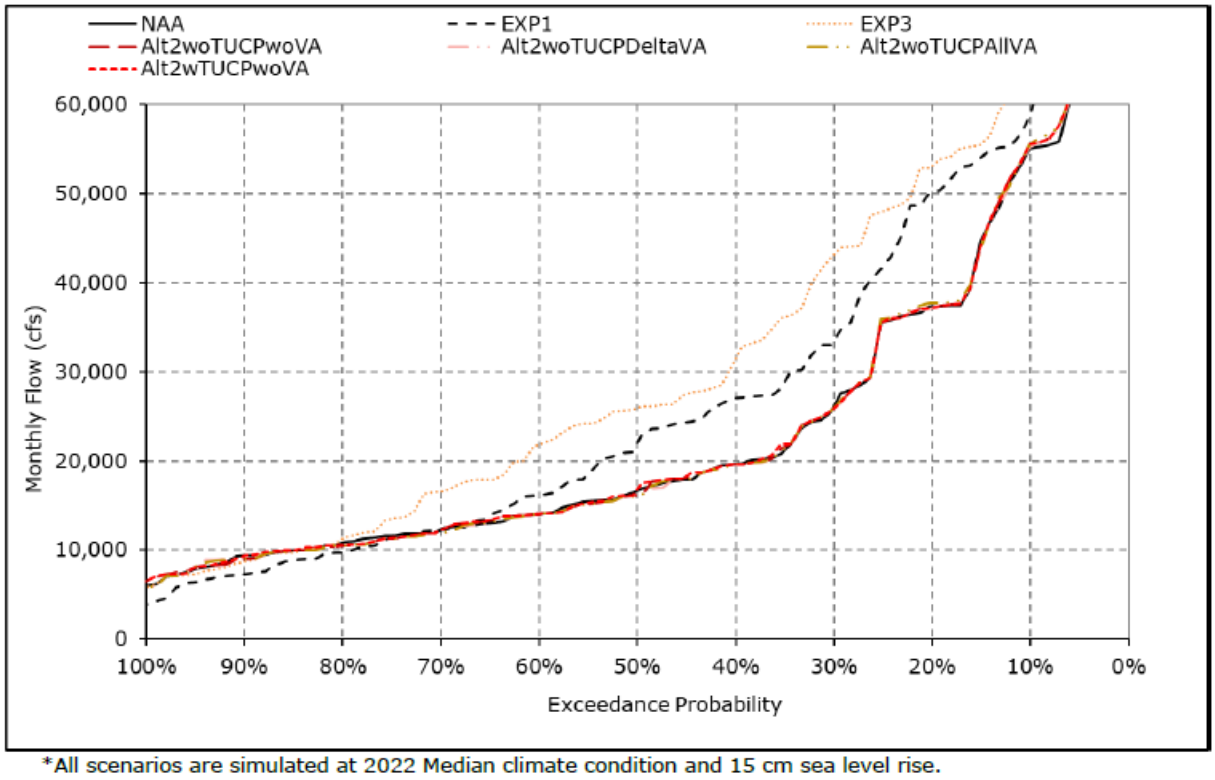


Figure 130. Exceedance plot of modeled Sacramento River Flow (cubic feet per second) at Freeport during December.

Source: Figure F.2.2-14-9 from Appendix F, Attachment 2-2 in (U.S. Bureau of Reclamation 2023-2024)

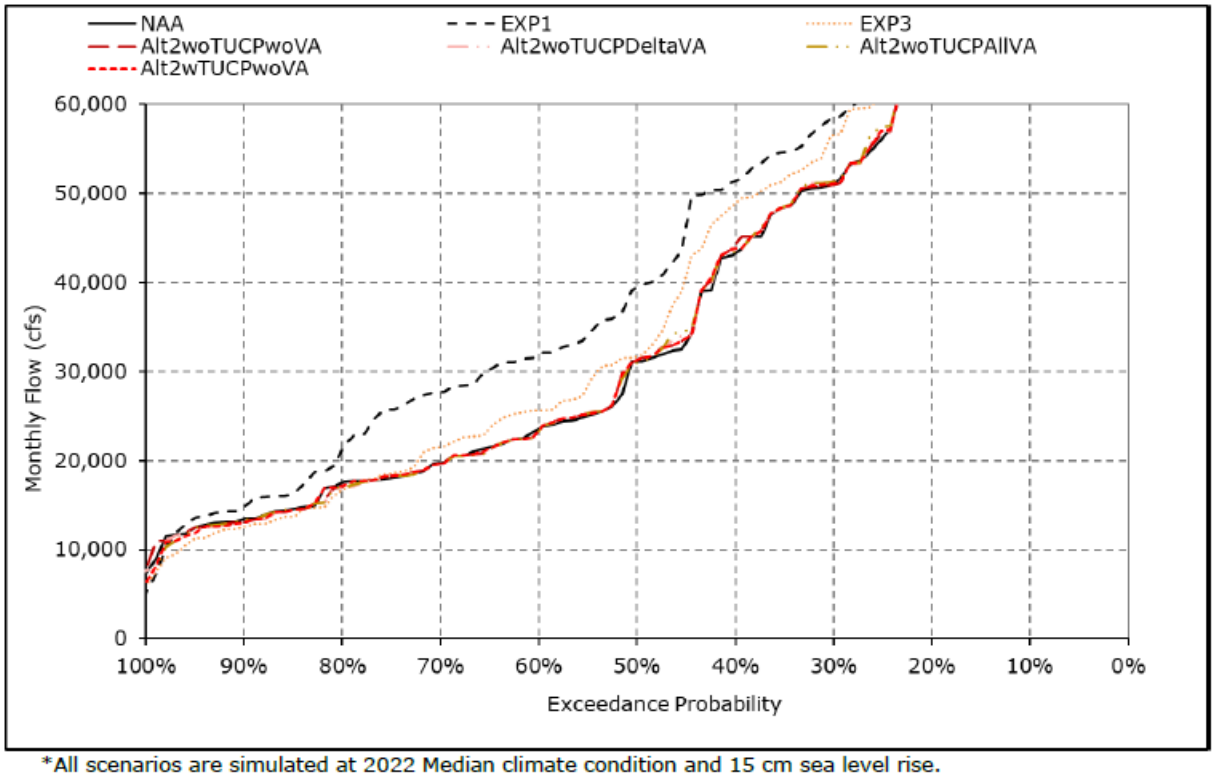


Figure 131. Exceedance plot of modeled Sacramento River Flow (cubic feet per second) at Freeport during February.

Source: Figure F.2.2-14-11 from Appendix F, Attachment 2-2 in (U.S. Bureau of Reclamation 2023-2024)

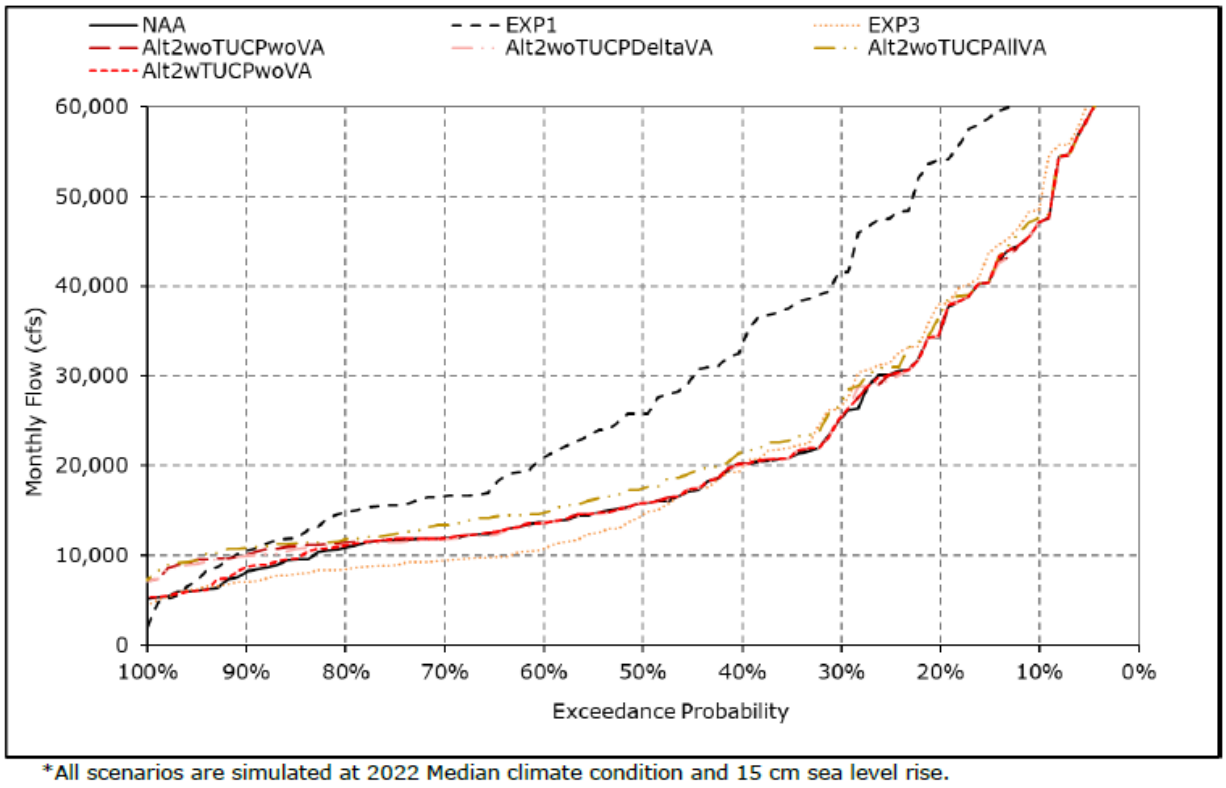


Figure 132. Exceedance plot of modeled Sacramento River Flow (cubic feet per second) at Freeport during April.

Source: Figure F.2.2-14-13 from Appendix F, Attachment 2-2 in (U.S. Bureau of Reclamation 2023-2024)

The overall Delta survival of fish entering the Delta at Freeport is shown by month in Figure 133. As expected, the key patterns are the opposite of the patterns in routing to the interior Delta, since routing to the interior Delta is associated with lower survival. Note that higher Freeport flows increase overall Delta survival in the STARS model both via a smaller proportion of individuals routing into lower survival interior Delta routes and also via increased survival as a function of flow within a given route.

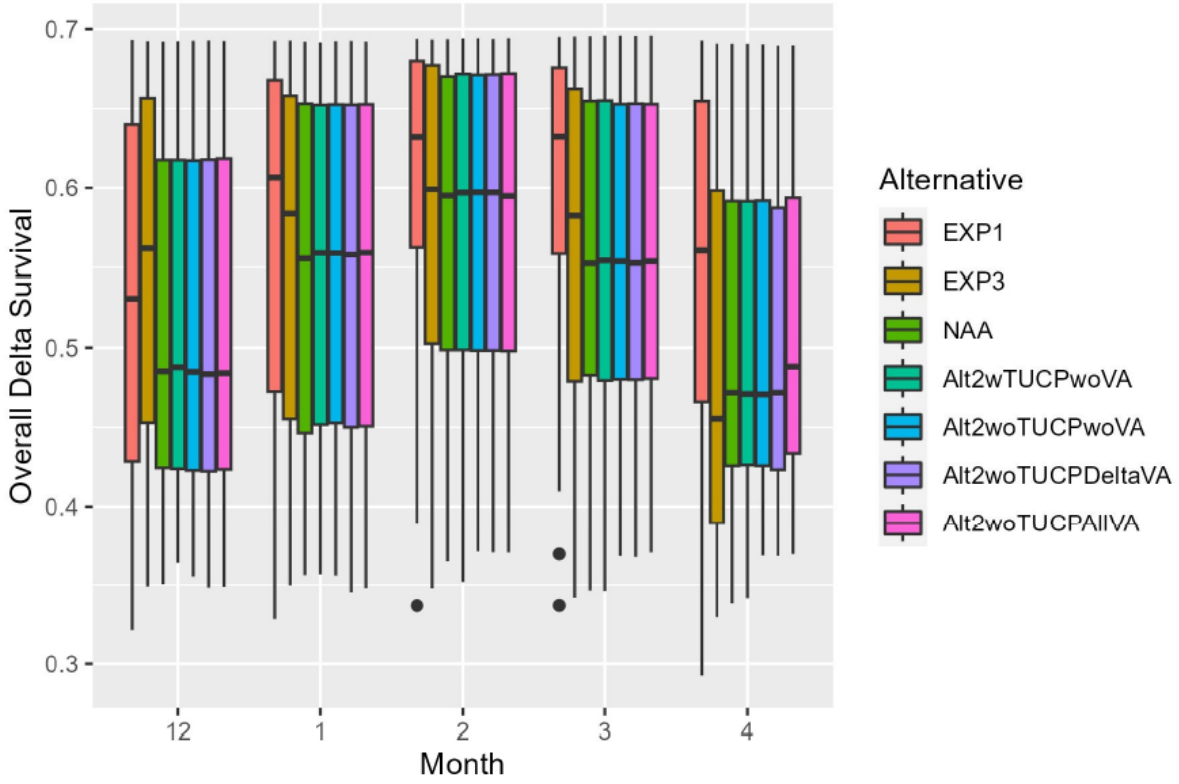


Figure 133. Boxplots of predicted mean survival across all routes for relevant migratory months. The box edges represent 25th and 75th percentiles, and whiskers are the product of the interquartile range and 1.5.

Source: Figure 16 from Appendix I, Attachment X - STARS model in (U.S. Bureau of Reclamation 2023-2024)

7.5.1.3.3. Delta Passage Model

The DPM simulates the migration of Chinook salmon smolts entering the Delta from the Sacramento River, Mokelumne River, and San Joaquin River and provides estimates of survival to Chipps Island. For Reclamation's BA (U.S. Bureau of Reclamation 2023-2024), only the survival of fish entering the Delta from the Sacramento River was evaluated. The DPM uses available time-series data and values taken from empirical studies or other sources to parameterize model relationships and inform uncertainty, thereby using the greatest amount of data available to dynamically simulate responses of smolt survival to changes in water management.

Although the survival estimates generated by the DPM are not intended to predict current or future outcomes, the DPM provides a simulation tool that compares the effects of different water management operations on smolt migration survival, with an estimate of uncertainty. While it is possible that underlying relationships (e.g., flow-survival) that are used to inform the DPM may change, it is assumed that these basic relationships are static to allow scenarios to be compared to one another for the current analysis.

DPM results are primarily used to inform understanding of the effect of the proposed action on the through-Delta survival of smolts entering the Delta from the Sacramento River. The major model functions in the DPM are as follows.

- Delta Entry Timing, which models the temporal distribution of smolts entering the Delta for each of the four runs of CV Chinook salmon
- Fish Behavior at Junctions, which models fish movement as they approach river junctions
- Migration Speed, which models reach-specific smolt migration speed and travel time
- Route-Specific Survival, which models route-specific survival response to non-flow factors
- Flow-Dependent Survival, which models reach-specific survival response to flow
- Export-Dependent Survival, which models survival response to water export levels in the interior Delta reach

Detailed results and more information on model structure are provided in "Appendix I – Old and Middle River Management, Delta Passage Model: A Simulation Model of Chinook Salmon Survival, Routing, and Travel Time in the Sacramento–San Joaquin Delta" (OMR Delta Passage Model.pdf), provided as part of the BA (U.S. Bureau of Reclamation 2023-2024). Excerpted below are selected results showing general conclusions from the DPM analysis.

- Mean predicted survival to Chipps Island, averaged by water year type, of SR winter-run and CV spring-run Chinook salmon is presented in Table 112 and Table 113 (respectively). Overall results show that survival values range from 0.26 to 0.33 for the proposed action, depending on water year type. Within each scenario, estimated through-Delta survival increases progressively with wetter hydrology, with the lowest survival in critical water years and the highest survival in wet water years.
- Relative to the NAA, the proposed action provides similar rates of survival to Chipps Island. Relative to the EXP3, the proposed action results in small decreases in mean survival to Chipps Island for SR winter-run and CV spring-run Chinook salmon.

Table 112. Mean predicted Sacramento River winter-run Chinook salmon survival to Chipps Island averaged by water year type.

Water Year Type	Run	NAA	Alt2v1 (proposed action year 3 onward)	Alt2v2 (proposed action first 2 years)	EXP3
Above Normal	Winter	0.26	0.26	0.26	0.30
Below Normal	Winter	0.20	0.20	0.20	0.23
Critical	Winter	0.14	0.15	0.15	0.15
Dry	Winter	0.17	0.17	0.17	0.20
Wet	Winter	0.33	0.33	0.33	0.37

Table 113. Mean predicted Central Valley spring-run Chinook salmon survival to Chipps Island averaged by water year type.

Water Year Type	Run	NAA	Alt2v1 (proposed action year 3 onward)	Alt2v2 (proposed action first 2 years)	EXP3
Above Normal	Spring	0.27	0.27	0.27	0.29
Below Normal	Spring	0.20	0.20	0.20	0.22
Critical	Spring	0.13	0.14	0.14	0.14
Dry	Spring	0.18	0.18	0.18	0.19
Wet	Spring	0.33	0.33	0.33	0.36

Figure 134 shows the Delta entry timing used in the DPM analysis. Specifically, CV spring-run Chinook salmon juveniles were modeled to enter the Delta from March through May, while SR winter-run Chinook salmon juveniles were modeled to enter the Delta from December through April. The difference in Delta entry timing means that the different runs of Chinook salmon may experience different Delta hydrodynamics. Because these fish are modeled to enter the Delta from the north, the modeled Freeport flows are particularly relevant for modeled through-Delta survival since those flows affect both routing into the interior Delta and survival of fish that do not enter the interior Delta. The modeled Freeport flow data in Figure 123 (which is averaged for each month across all years in the CalSim period of record), indicate that CV spring-run Chinook salmon juveniles may have experienced slightly lower Freeport flows on average, especially in April and May compared to Freeport flows experienced by SR winter-run Chinook salmon juveniles migrating in, on average, wetter months including January through March. Nonetheless, the estimated through-Delta survival is almost identical for CV spring-run and SR winter-run Chinook salmon juveniles, even with the differences in Delta entry timing and seeming differences in Freeport flow. NMFS's conceptual model would suggest that the lower survival expected for CV spring-run Chinook salmon at lower Freeport flows in April and May is offset by the more suitable hydrodynamic conditions in the South Delta for any CV spring-run Chinook salmon that entered the interior Delta at that time, since exports (Figure 125) were lower and OMR flows (Figure 126) were more positive in April and May compared to earlier months. However, the DPM model uses a flat to slightly positive relationship of survival to exports (when accounting for Freeport flow variation), so South Delta conditions do not explain those DPM results. It is likely that the variation in conditions depending on month and water year type are such that the average conditions across all years do not reflect the overall survival patterns that occur over the period of record.

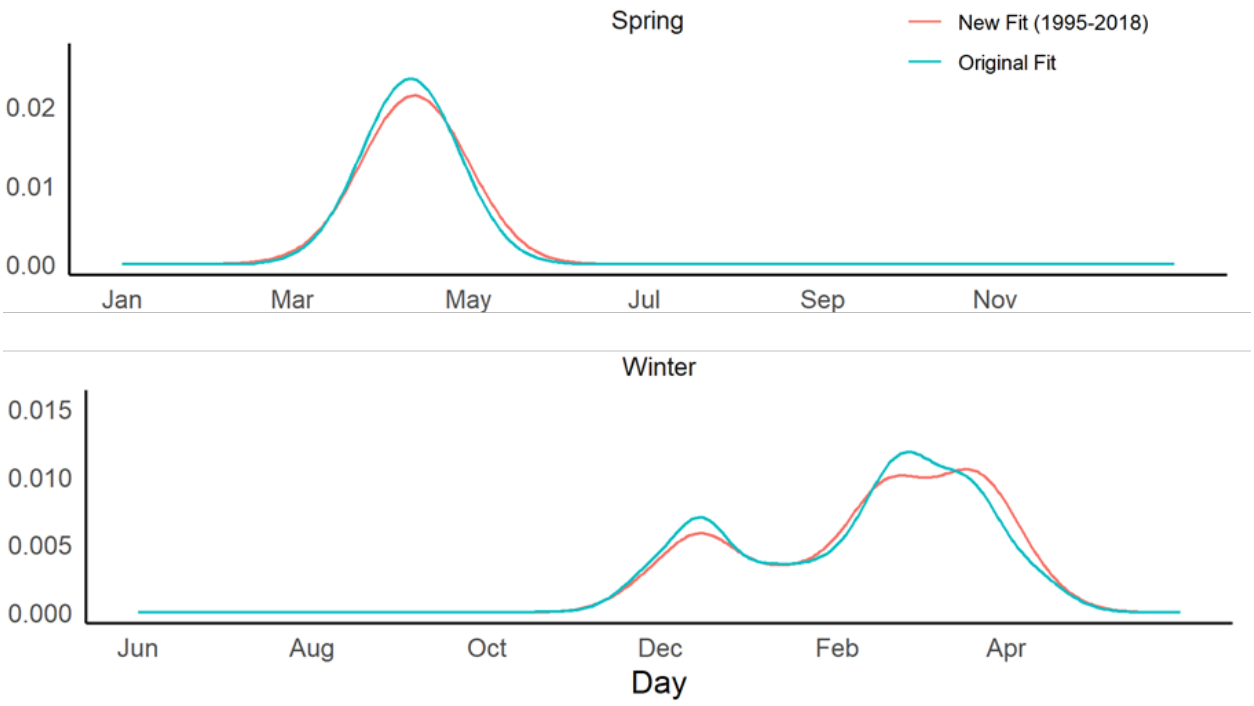


Figure 134. Delta entry (into the North Delta on the Sacramento River) distributions for Chinook salmon smolts applied in the Delta Passage Model for Sacramento River winter-run Chinook salmon and Central Valley spring-run Chinook salmon.

Source: Modified from Figure 2 in "Appendix I – Old and Middle River Management, Delta Passage Model: A Simulation Model of Chinook Salmon Survival, Routing, and Travel Time in the Sacramento–San Joaquin Delta" (U.S. Bureau of Reclamation 2023-2024)

7.5.1.3.4. Old and Middle River ECO-PTM

ECO-PTM is an enhanced version of the particle tracking model (PTM) that includes user-imparted swimming behaviors for the simulated neutrally buoyant particles (Wang et al. In Press). The PTM is a module of the Delta Simulation Model 2 (DSM2) that uses hydrodynamics simulated by DSM2 to simulate the movement of neutrally buoyant particles in the Delta. The DSM2 model, in turn, relies on hydrological inputs generated by CalSim. Additional swimming behaviors associated with the neutrally buoyant particles in ECO-PTM include upstream or downstream movement, holding behaviors, and swimming velocity at 15-minute intervals; these behaviors were parameterized by calibrating ECO-PTM to observed travel time data through multiple reaches in the Delta from acoustic telemetry studies on Chinook salmon smolts. ECO-PTM also includes probabilistic particle routing at several junctions along the mainstem of the Sacramento River (i.e., Sutter Bypass, Steamboat Slough, Delta Cross Channel, and Georgiana Slough), informed by observed routing data from acoustic telemetry studies on Chinook salmon smolts in the December to March timeframe. Furthermore, the model characterizes the following particle fates: proportional routing through either the Sutter Bypass, Steamboat Slough, Delta Cross Channel, Georgiana Slough, or mainstem Sacramento River; travel times through each route based on the timing of both entry into each reach and exit past Chipps Island (i.e., only particles that exit the Delta are included); and survival. Survival for each reach is modeled using

an XT model, in which survival is modeled as a function of travel time and reach length, which was parameterized using estimated survival from acoustic telemetry data.

ECO-PTM results are used to describe proposed action effects to Delta routing and survival at the major junctions of the Sacramento River.

Detailed results are provided in "2024-01-12 OMR ECO-PTM.pdf," provided as part of the BA (U.S. Bureau of Reclamation 2023-2024). Excerpted below are selected results showing general conclusions from the ECO-PTM analysis:

- No survival or routing results provided for any OMR flow that did not fall into one of the preassigned bins (e.g., -2,000 cfs, -3,500 cfs, -5,000 cfs and more negative than -5,500 cfs). OMR flows more positive than -1,500 cfs were not evaluated.
- No survival or routing estimates are provided for the Delta Cross Channel reach, as during the December to March timeframe the Delta Cross Channel would be closed.
- Overall, probabilistic particle routing is greatest in the mainstem Sacramento River regardless of OMR or inflow bins.
- When sorted by inflow bins, routing into Sutter and Steamboat sloughs is greater than into Georgiana Slough when Sacramento River inflow is "high," while the inverse is true when Sacramento River inflow is "medium" or "low."
- When sorted by OMR bins, routing into Georgiana Slough is greater, relative to the other available routes, excluding the mainstem Sacramento River when OMR flows are greatest and weakest (i.e., more negative than -5,500 and -2,000 cfs). When OMR flows are moderate (i.e., -3,500 or -5,000 cfs), routing (excluding the mainstem Sacramento River) is greatest into Sutter and Steamboat sloughs.
- Survival results generally suggest that fish migrating through Steamboat Slough experience the highest survival, followed by the mainstem Sacramento River and Sutter Slough. Georgiana Slough has the lowest survival probability regardless of inflow or OMR bins modeled.

The reporting of estimated results by OMR or inflow bin makes sense in that those flow measures are key drivers of survival and are affected by project operations. However, since a specific OMR or inflow bin represents a specific hydrodynamic condition, it is not surprising that similar survival results are observed for each OMR or inflow bin, regardless of which modeling scenario is being evaluated. To evaluate how overall survival might differ across scenarios, what matters is the estimated frequencies of the OMR or inflow bins across the modeling period of record. Twelve months over the 100-year period of record means that there are 1,200 monthly OMR or inflow combinations that can be sorted into bins. The details on the OMR and inflow bins are provided in Appendix I_Attachment X - Delta Export OMR Zone of Influence Analysis (U.S. Bureau of Reclamation 2023-2024). Overall, Table 114 shows that modeled OMR flows differ depending on the phase of proposed action implementation, with OMR more positive than -1,500 cfs in 15 percent of months in phase 1 of the proposed action (with foregone CVP and SWP exports) and in 9 percent of months during phase 2 of the proposed action (which is expected to begin in year 3, with no Delta VA implementation). That is, in 85 percent to 91 percent of months under proposed action conditions, the average monthly net flow in the OMR corridor is in the upstream, rather than downstream (and oceanward) direction. While the OMR corridor is naturally tidal and a natural hydrograph would include negative instantaneous flows, the observed frequency of net negative flows is a notable deviation

from the natural hydrograph. For context, the NAA scenario shows OMR more positive than -1,500 cfs in 13 percent of years. According to the CalSim Trend worksheet for the September 7, 2023, run, 100 percent of months in the EXP3 scenario have OMR flows more positive than -1,500 cfs, and 69 percent of months (825 out of 1,200 months) have net positive OMR flows.

The survival results must be caveated with the limitation that the patterns of survival include no information from OMR levels that are more positive than -1,500 cfs or that fall into the ranges of -2,500 to -3,000 cfs or -4,000 to -4,500 cfs. Those exclusions represent 42 percent of months in phase 1 of the proposed action (Alt2v2), and 39 percent of months in phase 2 of the proposed action (Alt2v1), and 100 percent of months in the CalSim record for the EXP3 scenario.

Table 114. Proportion of dataset excluded from analysis based on CalSim 3 output. Old and Middle River (OMR) values in the "Other" bin fall between -2500 to -3000 and -4000 to -4500 cubic feet per second (cfs). While not listed in the table, all of the EXP3 output is excluded from analysis since 100 percent of monthly OMR values are more positive than -1,500 cfs.

OMR	NAA	Alt2v1 (proposed action year 3 onward)	Alt2v2 (proposed action first 2 years)	EXP3
More positive than -1500	0.13	0.09	0.15	1.0
Other	0.2	0.3	0.27	0.0

Source: Table 5 from Appendix I_Attachment X - Delta Export OMR Zone of Influence Analysis in (U.S. Bureau of Reclamation 2023-2024)

7.5.1.3.5. Export/Old and Middle River Zone of Influence

Reclamation has also provided an analysis of the spatial extent of the influence of exports under CVP and SWP diversions using DSM2-HYDRO. Specifically, the typical DSM2-HYDRO velocity results were used to generate Delta export zone of influence contour maps in the Delta. This analysis is used to explore the drivers of hydrologic alteration for a discrete set of OMR levels and inflow categories standardized across nine combinations of San Joaquin and Sacramento River inflows, using DSM2 modeling and post-processing steps to quantify the influence of the export facilities in the South Delta. Probability density curves of hourly average velocity at specific locations were created for pumping (export) and no pumping conditions where the proportion overlap of the curves was used as a comparative metric to capture the effects of exports (e.g., greater overlap attributed to less of an effect). Then, based on proportion overlap, two methods for evaluating Delta export zone of influence were presented for differing inflow groups and OMRs: (1) maps that illustrate the spatial extent of changes to velocity throughout the Delta, and (2) figures that illustrate the proportion of channel lengths influenced by exports.

The Export/OMR Zone of Influence modeling results are used to inform the spatial extent of the exposure of species to modified hydrodynamics in the Delta as a result of project-related exports.

Detailed results are provided in "Appendix I_Attachment X - Delta Export OMR Zone of Influence Analysis.pdf," as part of the BA (U.S. Bureau of Reclamation 2023-2024). Excerpted below are selected results showing general conclusions from the Zone of Influence analysis.

- Figure 113 and Figure 114 show that across all alternatives, most of the DSM2 nodes experienced low hydrologic influence (greater than 0.75 overlap). The spatial extent (sum and proportion of channel length) channel length altered across the proposed action components ranges from 45,576 feet (1.2 percent of the DSM2 grid in Alt2v2) to 583,403 feet (15.2 percent of the DSM2 grid in Alt2v3). The greatest extent of hydrologic alteration occurs in the more negative than -5500 OMR bin, which is likely associated with greater exports.
- Channel length altered and Delta Export zone of influence generally increased with more negative OMR. These trends appear consistent across inflow groups containing combinations of low and medium Sacramento and San Joaquin River inflow (lolo, lomed, medlo, and medmed inflow groups). At high Sacramento River inflow (hilo, himed, and hihi inflow groups), there appears to be little difference in proportional channel length altered between -5000 and the more negative than -5500 OMR bins. In the lohi and hihi inflow groups, there also appears to be less difference in proportional channel length altered across all OMR bins.

7.5.1.3.6. Old and Middle River Flow Into Junction Analysis

There is strong evidence that routing at junctions is a function of the proportion of flow into that junction (Perry et al. 2010, Cavallo et al. 2015). Thus, estimating the proportion of flow entering a Delta junction can be strongly predictive of the proportion of migrating salmonids that may move from the main channel into a distributary via that junction. The Flow Into Junction Analysis rolls up the daily proportion of flow entering a distributary junction into monthly values, where increases in the proportion of flow into a distributary channel under alternative scenarios would allow one to evaluate the likelihood of fish migration into junctions. This analysis of flow routing into junctions is based on the proportion of flow entering a junction away from the mainstem estimated from DSM2-HYDRO outputs. Fifteen-minute data are used to calculate the daily proportion of flow that enters the junction, following the methods of (Cavallo et al. 2015). The daily value calculated from the 15-minute data is then used to calculate summary statistics for each month (December–June) and water year type.

Because this method is a way of summarizing data from the DSM2 model, the assumptions and uncertainties that apply to the DSM2 model would also apply to this analysis. Furthermore, interpretations of the Flow Into Junctions Analysis assume that fish arrive at the junction uniformly over the 24-hour averaging period because flow routing is averaged over the 24-hour period to account for sub-daily changes (e.g., tidal influence). Additionally, it must be assumed that the behavior of fish at junctions is the same over the range of hydrologic conditions modeled (e.g., the relationship is linear across the range of data).

These modeling results are used to assess changes in the potential risk of entrainment into the interior and south Delta as it relates to project operation scenarios.

Detailed results are provided in "Appendix I. OMR Flow into Junction Analysis.pdf," provided as part of the BA (U.S. Bureau of Reclamation 2023-2024). Excerpts below are selected results showing general conclusions from the Flow Into Junctions Analysis:

- Figure 135 shows a decreasing proportion of flow entering Georgiana Slough from the mainstem Sacramento River as the Sacramento River inflow group increases for all alternatives

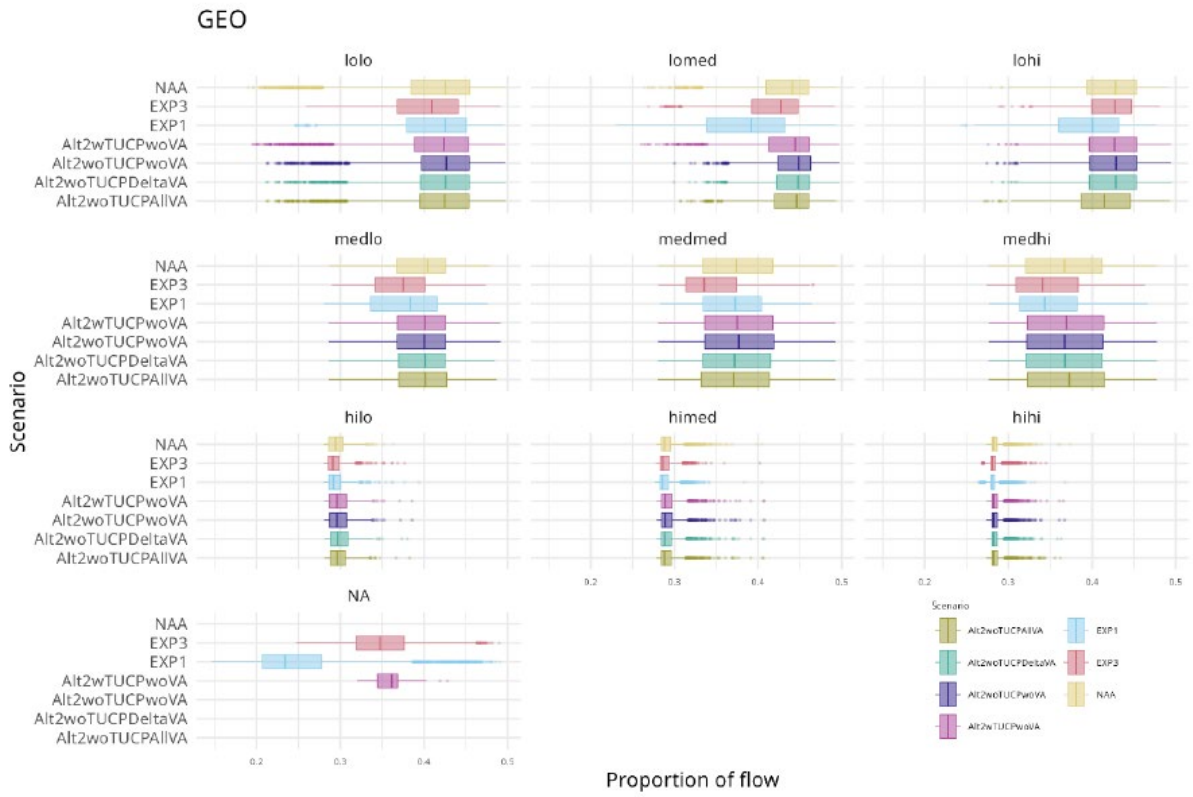


Figure 135. Proportion of flow entering Georgiana Slough (GEO) from DSM2-HYDRO modeling data for all alternatives by inflow group.

Source: Appendix I. OMR Flow into Junction Analysis.pdf in (U.S. Bureau of Reclamation 2023-2024)

- Figure 136 shows a decreasing proportion of flow entering Head of Old River from the San Joaquin River as the San Joaquin inflow group increases for all alternatives



Figure 136. Proportion of flow entering Head of Old River (HOR) from DSM2-HYDRO modeling data for all alternatives by inflow group.

Source: Appendix I. OMR Flow into Junction Analysis.pdf in (U.S. Bureau of Reclamation 2023-2024)

- Although slight, junctions to the east of the mouth of Old River show decreasing proportion of flow entering the interior and south Delta with increasing San Joaquin River flows, while the proportion of flow entering the mouth of Old River appears to increase with increasing Sacramento River flow
- When binned by OMR, the proportion of the flow entering the Georgiana Slough junction was reduced as OMR became more negative but was then greatest for OMR more negative than -5500 cfs
- At Head of Old River, the proportion of flow entering the junction increased as OMR became more negative

7.5.1.3.7. Old and Middle River Volumetric Influence Analysis

A range of potential hydrodynamic influence (i.e., volumetric influence analysis) can be estimated by calculating the fraction of Delta inflow that is diverted by the CVP and SWP export facilities. Using this method, hydrodynamic influence is described as a ratio of Delta inflow to the combined export volume. This approach provides a coarse (monthly) estimate of the amount of influence exerted on the natural hydrodynamics of the Delta through changes in exports over a suite of operational scenarios for the months of December through June, which is representative

of OMR management actions. In practice, such actions are implemented to protect fish, water quality, and meet other requirements through the manipulation of export rates of the CVP and SWP. Through examining the total exports relative to the total Delta inflow estimated through CalSim 3 modeling among different scenarios, an estimated range of hydrodynamic influence for each scenario is created. A critical assumption of this analysis is that as a larger percent of Delta inflow is exported, more of the habitat in the Delta will be under the influence of change in hydrodynamics. Furthermore, the analysis provided by Reclamation assumes less hydrodynamic influence is better for listed fish species.

The OMR Volumetric Influence Analysis provides an assessment of the inflow-to-export ratio of a given project operation scenario, relative to other operational scenarios, that can be used to inform a qualitative comparison of alternatives.

Detailed results are provided in "Appendix I_Attachment X - OMR Volumetric Influence Analysis.pdf," provided as part of the BA (U.S. Bureau of Reclamation 2023-2024). Excerpted below are selected results showing general conclusions of the Volumetric Influence Analysis:

- The influence value of EXP3 is zero for all months and water year types considered because the scenario does not include south Delta exports.
- When results were grouped by water year, the observed lowest mean (non-zero) percent Delta inflow exported—20 percent—was observed in wet and above normal years for Alt2v2 and in wet years for Alt2v1. The lowest minimum (non-zero) value—1.7 percent—was observed in wet years for both Alt2v2 and Alt2v1. The greatest maximum value of 65 percent was observed in wet, above normal, and critically dry year types in Alt2v2, and in wet and above normal year types in Alt2v1.
- When grouped by water year type, Alt2v1 has a higher frequency peak of slightly above 20 percent Delta inflow in below normal and dry years relative to the other alternatives (Figure 137). Within critically dry years, all alternatives overlap in frequency near 20 percent, and it is difficult to separate which frequency is greatest.
- The distribution of the percent Delta inflow exported is explained by operational constraints of the CVP and SWP. No more than 65 percent of Delta inflow may be exported at any time per D-1641, and in critically dry years, operations to meet human health and safety are maximized to meet that need when Delta inflow would be at its lowest.

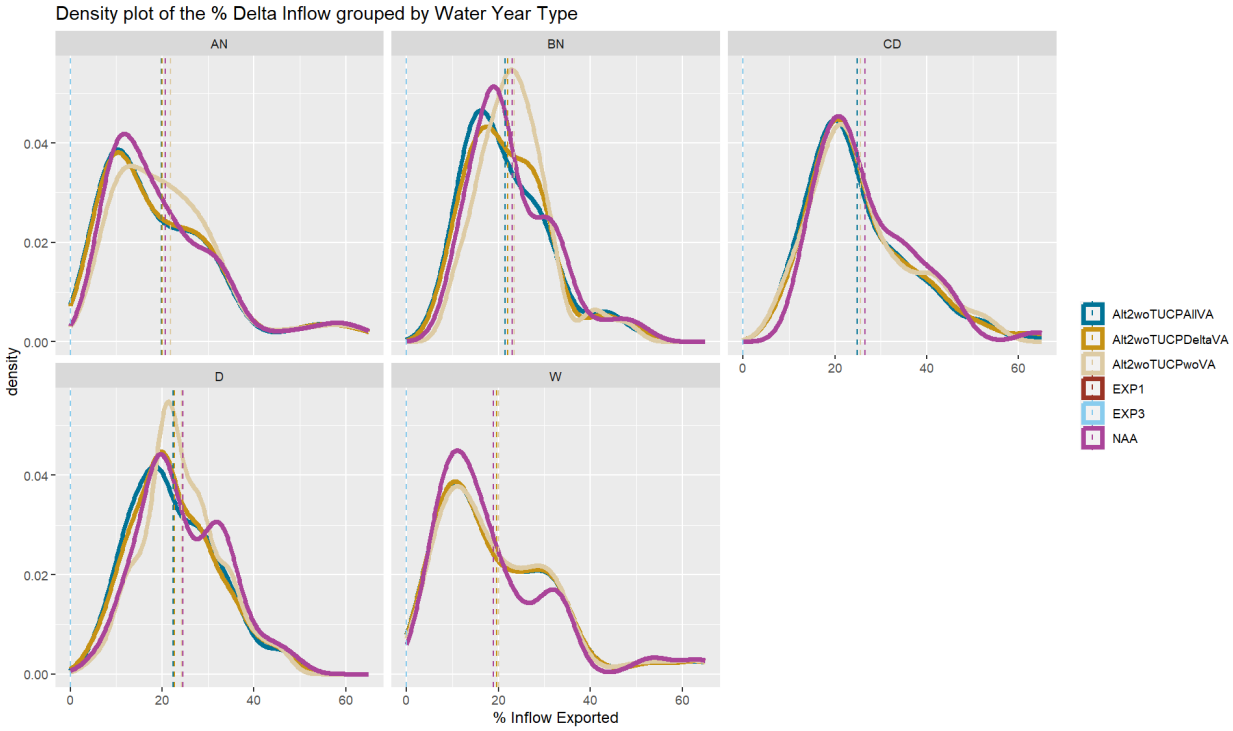


Figure 137. Kernel density estimate of each alternative's modeled monthly percent Delta inflow grouped by water year type.

Source: Appendix I_Attachment X - OMR Volumetric Influence Analysis.pdf in (U.S. Bureau of Reclamation 2023-2024)

7.5.1.3.8. Old and Middle River Coded Wire Tag Salvage Model

The Winter-Run Chinook Salmon CWT Proportional Salvage Model was developed to estimate the fraction of juvenile SR winter-run Chinook salmon in the Delta predicted to be salvaged based on hydrologic conditions and fish size. This model, specific to SR winter-run Chinook salmon, was constructed by Cavallo et al. (2015) and combined salvage at both the CVP and SWP rather than modeling them separately as was done in (Zeug and Cavallo 2014). When originally conceived, model selection included five potential hydrologic predictor variables, including OMR flow, inflow-export ratio, total exports (CVP and SWP combined), San Joaquin River flow, Sacramento River flow, and one biological variable (mean fork length at release). Ultimately, the final iteration of the model includes three predictor variables: mean fork length of fish at release, Sacramento River flow, and total exports by month (October–May).

Key assumptions associated with modeling result interpretation are that the relationships developed with hatchery-origin SR winter-run Chinook salmon are applicable to natural-origin SR winter-run Chinook salmon and that the relationships developed within the time period of the SR winter-run Chinook salmon CWT releases would apply to time periods and conditions outside of the CWT releases that SR winter-run Chinook salmon are still in the Delta.

This model is primarily used to estimate the number of SR winter-run Chinook salmon salvaged at the export facilities based on conditions that covary with changes in the project-related factors

of Sacramento River flow and exports. The CWT Salvage Model is used to assess proposed action elements that affect Sacramento River flow and/or exports.

Detailed results are provided in "Appendix I_OMR_CWT_Salvage_Model.pdf," provided as part of the BA (U.S. Bureau of Reclamation 2023-2024). Excerpted below are selected results showing general conclusions of the CWT salvage density modeling results:

- Figure 138 shows the predicted combined salvage at the export facilities for each operational scenario and by water year type, which are also presented in Table 115.
- The EXP3 modeling scenario has zero salvage because they do not include exports as defined in their respective scenarios.
- In general, and as might be expected from a model where total exports is a predictor variable, the Alt2v2 and Alt2v3 scenarios have lower predicted mean salvage compared to Alt2wTUCPwoVA and Alt2v1. This difference is most pronounced in the above and below normal years.

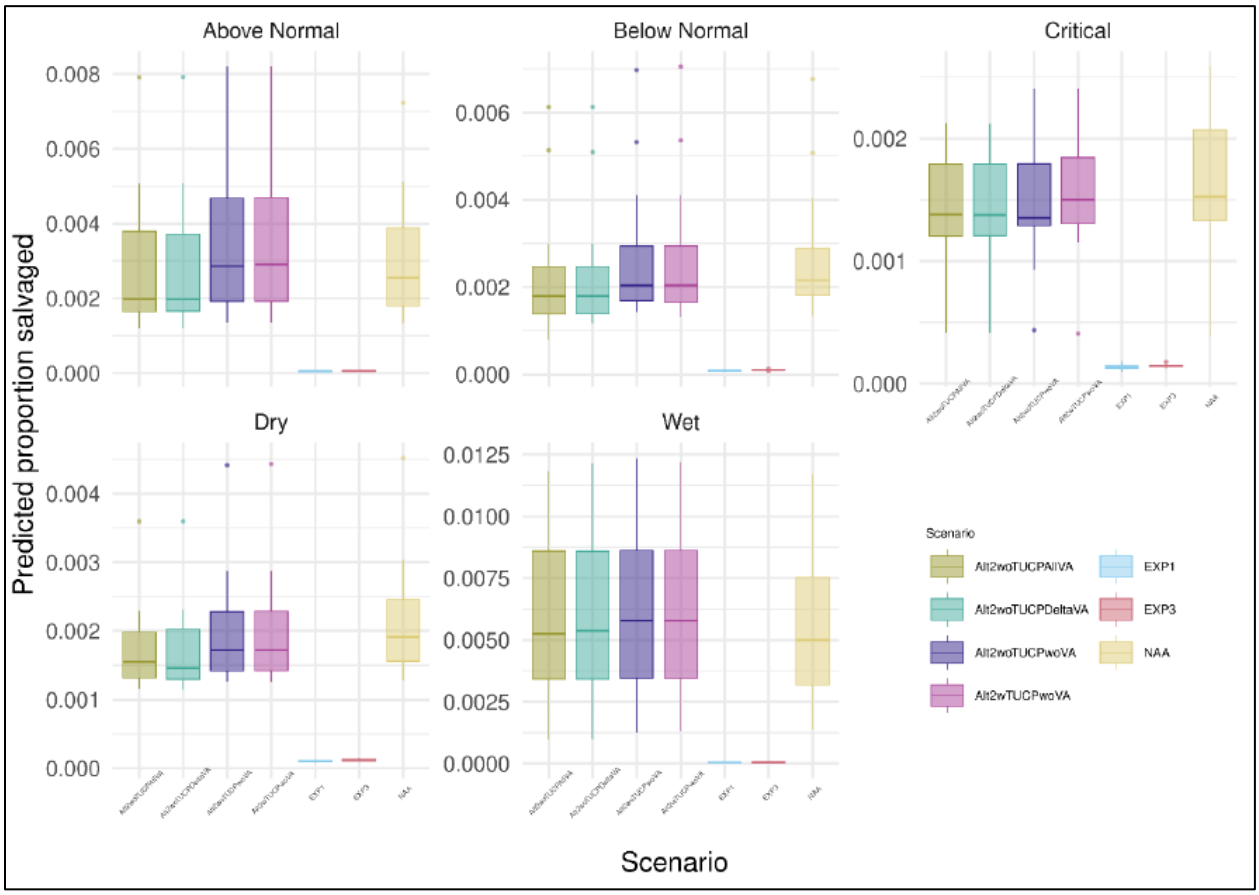


Figure 138. Boxplot of the predicted annual proportion of Sacramento River winter-run Chinook salmon salvaged at the Central Valley Project and State Water Project for all scenarios and all water year types.

Source: Appendix I_OMR_CWT_Salvage_Model.pdf in (U.S. Bureau of Reclamation 2023-2024)

Table 115. Coded Wire Tag Salvage Model, predicted mean of annual proportion of Sacramento River winter-run Chinook salmon salvaged at the Central Valley Project and State Water Project during different water year types.

Water Year Type	NAA	Alt2v1 (proposed action year 3 onward)	Alt2v2 (proposed action first 2 years)	EXP3
Above Normal	0.003	0.0034	0.0028	0.0001
Below Normal	0.0027	0.0027	0.0022	0.0001
Critical	0.0016	0.0015	0.0014	0.0001
Dry	0.0021	0.0019	0.0017	0.0001
Wet	0.0055	0.0062	0.0059	0.0000

Source: Appendix I_OMR_CWT_Salvage_Model.pdf in (U.S. Bureau of Reclamation 2023-2024)

7.5.1.3.9. Salvage density

The salvage-density method is a model of entrainment into the South Delta facilities as a function of flow based on historical salvage data. The results provide a quantitative assessment of differences in entrainment at the export facilities based on various operating scenarios. The method uses data from 2009 to 2022, which reflects the observed loss of salmonids at the CVP and SWP collection facilities and export rates. Results are provided by Delta pumping facility (Banks Pumping Plant and Jones Pumping Plant), by species (LAD SR winter-run Chinook salmon, genetic SR winter-run Chinook salmon, LAD CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon), and by water year type.

Despite the model being relatively straightforward, there are a number of assumptions necessary to support conclusions based on the results. Specifically, salvage from 2009 to 2022 is assumed to be representative of recent salvage patterns. For example, there were no above normal water year types 2009–2022, so wet water year types were considered to be representative of the missing above normal types of water years. Both clipped and unclipped juvenile salmonids included in the salvage record were used to inform the relationship between entrainment and flow such that that relationship is assumed to be representative of the ESU.

The salvage-density method provides outputs of fish lost but should not be treated as predictions of future entrainment. Instead, these results should be used to interpret differences between scenarios weighted by historical loss. The use of expanded salvage estimates has a known statistical error caused by the expansion of subsamples. This statistical error is not accounted for in the current salvage-density method, though it is consistent with analyses using these data. The method assumes a linear relationship between entrainment and export flows due to a lack of information on how salvage would increase with increasing flows. The method does not account for the spatial distribution of fish populations. Juvenile Chinook salmon were assigned a run using the LAD method, where there is a large overlap in size distributions among runs, which can lead to false assignments, and LAD has been shown to be inaccurate for both SR winter-run

and CV spring-run Chinook salmon when compared with genetic identification assignment. As such, salvage by run determined by LAD should be interpreted with caution. In this instance, the salvage density model was also run using juvenile Chinook salmon genetically identified as SR winter-run Chinook salmon.

This model is primarily used to consider differences in modeling scenarios (e.g., Alt2v1 vs. NAA) to inform how each would affect flows and predicted loss at the export facilities.

Detailed results are provided in "Appendix I_Attachment I.2 - OMR Salvage-Density Model Loss.pdf," provided as an appendix to the BA (U.S. Bureau of Reclamation 2023-2024). Excerpted below are selected results showing general conclusions of the salvage density analysis:

- Values from the exploratory modeling scenario EXP3 were not included for consideration in the range of mean predicted salvage because exports EXP3 are zero.
- The greatest predicted loss of LAD SR winter-run Chinook salmon at Banks Pumping Plant occurred in March, followed by February in wet and above normal water year types. In below normal water year types, the greatest predicted loss occurred in March for Alt2v1and in February for Alt2v2. Depending on the phase of Alternative 2, the greatest predicted loss occurred in February or March. In dry water year types, the greatest predicted loss of LAD SR winter-run Chinook salmon at Banks Pumping Plant occurred in March.
- The greatest predicted loss of genetic SR winter-run Chinook salmon at Banks Pumping Plant occurred in March, followed by February in wet and below normal water year types. In the above normal water year type, the greatest predicted loss also occurred in March, followed by February. In the dry water year type, the greatest predicted loss of genetic SR winter-run Chinook salmon at Banks Pumping Plant occurred in March, followed by April, with no loss occurring in any other months. Similarly, in critically dry water year types, the greatest loss of genetic SR winter-run Chinook salmon at Banks Pumping Plant occurred in April, followed by March, but only by a very small margin, with no loss occurring in any other months.
- The greatest predicted loss of LAD SR winter-run Chinook salmon at Jones Pumping Plant occurred in March, followed by February in wet and above normal water year types among components of Alternative 2. In below-normal water year types, depending on the component of Alternative 2, the greatest predicted loss occurred in February or March. In dry water year types, the greatest predicted loss of LAD SR winter-run Chinook salmon at Jones Pumping Plant occurred in March, followed by January and February (loss predictions from all versions of Alternative 2 are within a few fish). In critically dry water year types, the greatest loss of LAD SR winter-run Chinook salmon at Jones Pumping Plant occurred in March, followed by January.
- The greatest predicted loss of genetic SR winter-run Chinook salmon at Jones Pumping Plant occurred in March, followed by February in above normal and below normal water year types. In the wet water year type, the greatest predicted loss also occurred in March, followed by February. In the dry water year type, the greatest predicted loss of genetic SR winter-run Chinook salmon at Jones Pumping Plant occurred in March, with no loss occurring in any other months. Similarly, in critically dry water year types, the greatest loss of genetic SR winter-run Chinook salmon at Jones Pumping Plant occurred in

March, followed by January (for all alternatives), with no loss occurring in any other months.

- The greatest predicted loss of CV spring-run Chinook salmon at Banks Pumping Plant occurred in May, followed by April in wet and above normal water year types for all alternatives. In below normal and dry water year types, the greatest predicted loss occurred in April, followed by May. In critically dry years, the greatest predicted loss occurred in April, followed by March.
- The greatest predicted loss of CV spring-run Chinook salmon at Jones Pumping Plant occurred in May, followed by April in wet and above normal water year types in all alternatives. In below normal and dry water year types, the greatest predicted loss occurred in April, followed by May. In critically dry years, the greatest predicted loss occurred in April, followed by March.
- The greatest predicted loss of CCV steelhead at Banks Pumping Plant occurred in December, followed by January in wet, above normal, dry, and critically dry water year types. In below normal water year types, the greatest predicted loss occurred in January, followed by February.
- The greatest predicted loss of CCV steelhead at Banks Pumping Plant occurred in December, followed by January in wet, above normal, dry, and critically dry water year types. In below normal water year types, the greatest predicted loss occurred in January, followed by February.
- The mean predicted loss of sDPS green sturgeon at Banks Pumping Plant and Jones Pumping Plant from the salvage density model calculated across all water year types for each month and all alternatives has a narrow range. Ultimately, the historic occurrence of salvage of sDPS green sturgeon is rare. Southern DPS green sturgeon have been observed at Jones Pumping Plant in the months of June and July and at Banks Pumping Plant in the months of January and March. This temporal discrepancy between facilities makes it difficult to provide trends in monthly Sacramento River flows and combined OMR.

7.5.1.3.10. Negative Binomial Salvage Model

To evaluate potential changes to the number of LAD SR winter-run Chinook salmon, LAD CV spring-run Chinook salmon, and CCV steelhead salvaged at the CVP and SWP pumping facilities under different operations scenarios, Reclamation analyzed historical salvage data (January 1, 1993, through December 31, 2020) via negative binomial regression. Negative binomial regression requires an estimation of a dispersion parameter rather than assuming the variance is equal to the mean. In doing so, negative binomial regression can account for overdispersion, which is common in ecological data (e.g., the salvage dataset), as well as reduce the likelihood of biased coefficient estimation. The analysis assessed combined CVP and SWP loss as a function of Delta exports, Sacramento River flow, San Joaquin River flow, and OMR flow. For SR winter-run and CV spring-run Chinook salmon, catch data from the Sacramento Trawl was another variable considered. To focus on periods when the target species was most likely to be present in the salvage data, data from December to April was used for SR winter-run Chinook salmon analysis, data from March to June was used for CV spring-run Chinook salmon analysis, and data from December to June was used for CCV steelhead analysis.

Detailed results are provided in "Appendix I_Attachment I.1 - Negative Binomial Model.pdf," provided as part of the BA (U.S. Bureau of Reclamation 2023-2024). Excerpts below are

selected results of the Negative Binomial Salvage Model analysis for LAD SR winter-run Chinook salmon (Figure 139), LAD CV spring-run Chinook salmon (Figure 140), and CCV steelhead (Figure 141). There is a lot of overlap in predicted salvage levels in many months and year types, with specific directional changes in salvage depending on month and year type.

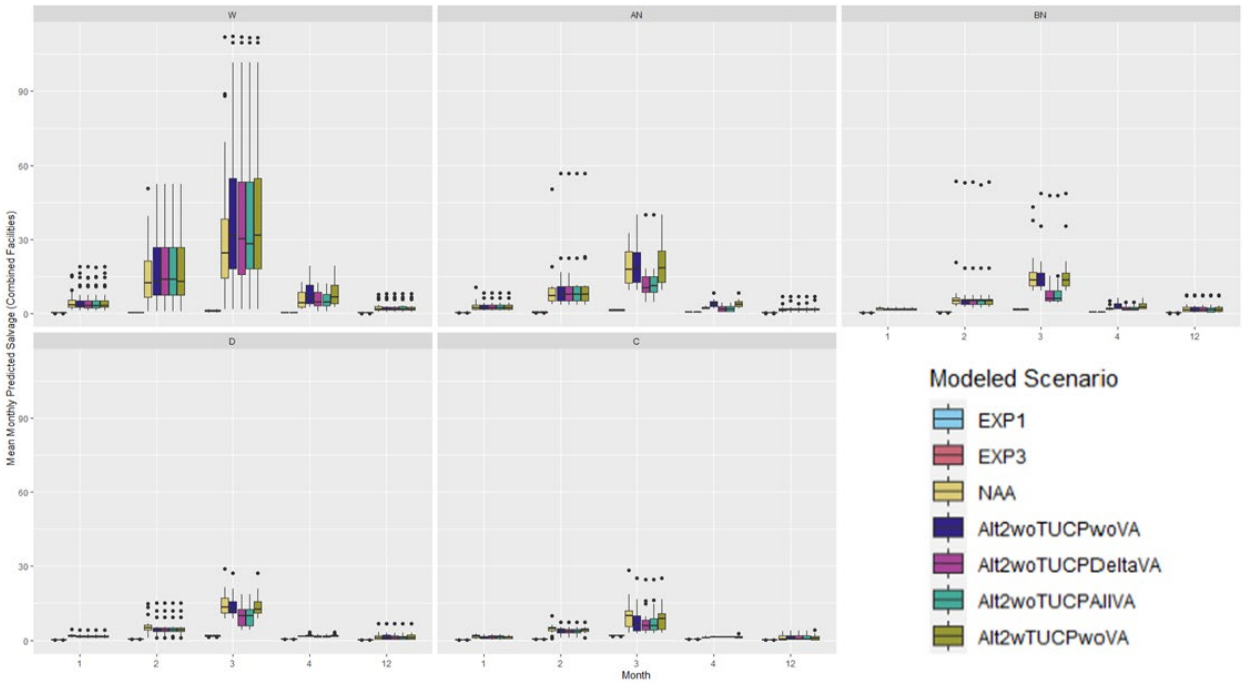


Figure 139. Modeled average monthly salvage of length-at-date Sacramento River winter-run Chinook salmon at the Delta fish collection facilities by water year type and month, based on the negative binomial salvage method. Note the y-axis scale is fixed.

Source: Modification of Figure 1 in Appendix I_Attachment I.1 - Negative Binomial Model in (U.S. Bureau of Reclamation 2023-2024)

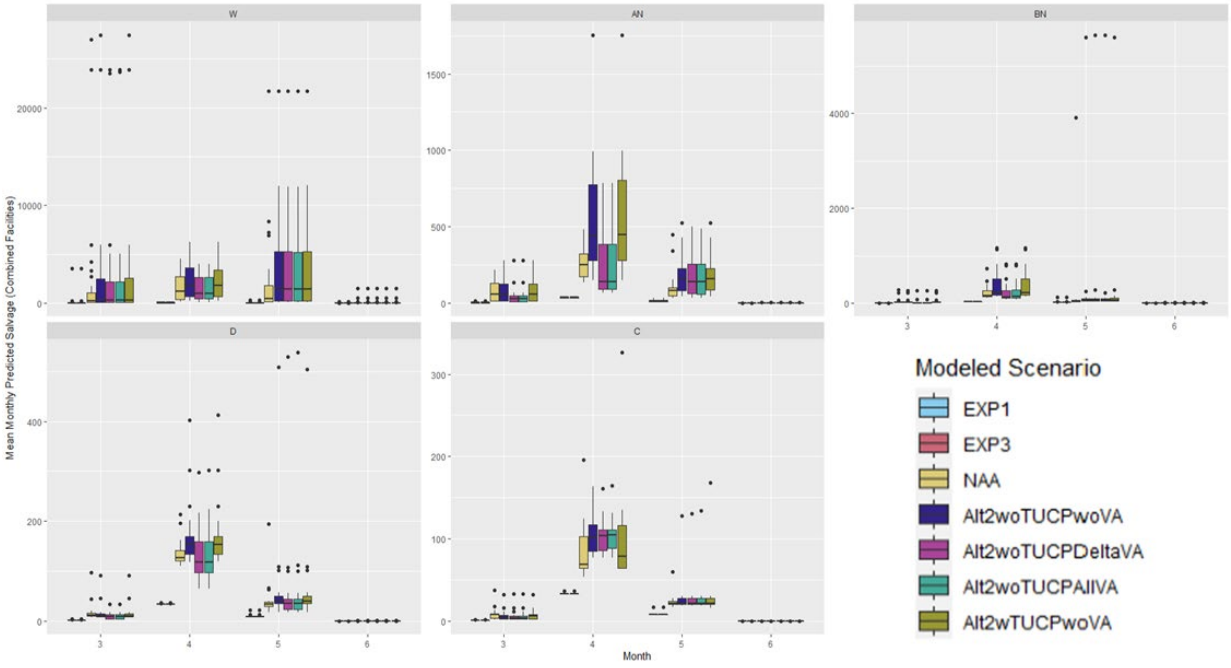


Figure 140. Modeled average monthly salvage of length-at-date Central Valley spring-run Chinook salmon at the Delta fish collection facilities by water year type and month, based on the negative binomial salvage method. Note the y-axis scale is free.

Source: (Modification of Figure 3b in Appendix I_Attachment I.1 - Negative Binomial Model in (U.S. Bureau of Reclamation 2023-2024)

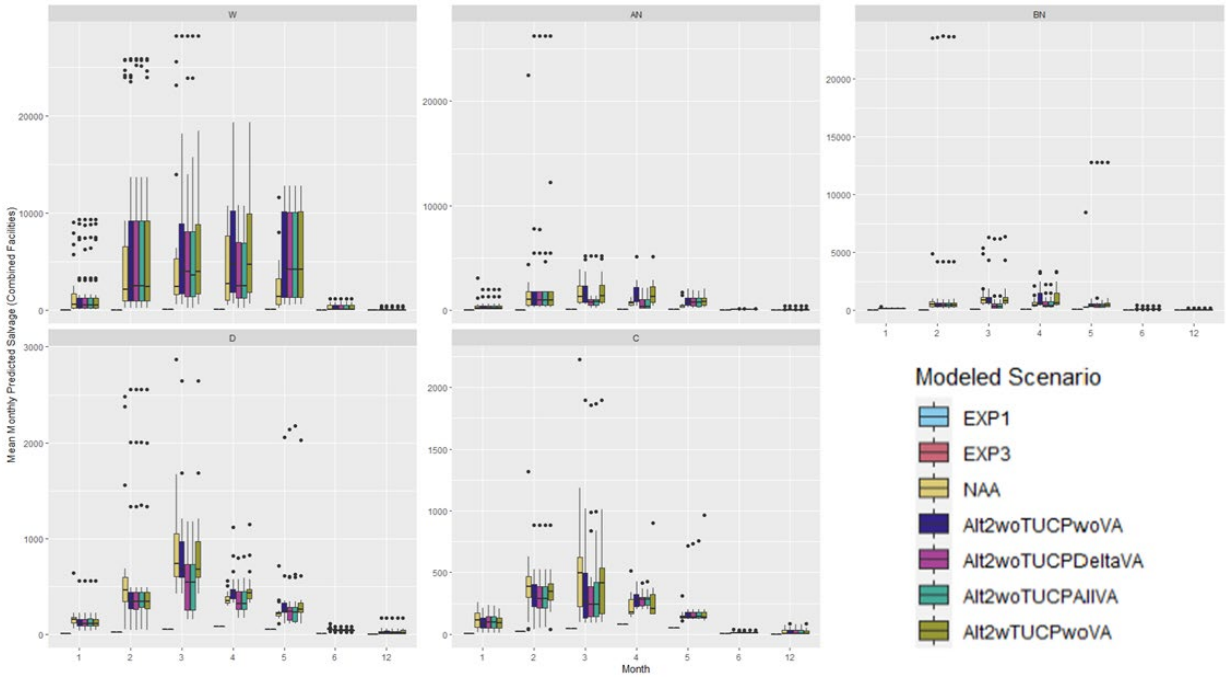


Figure 141. Modeled average monthly salvage of California Central Valley steelhead at the Delta fish collection facilities by water year type and month, based on the negative binomial salvage method. Note the y-axis scale is free.

Source: Modification of Figure 5b in Appendix I_Attachment I.1 - Negative Binomial Model in (U.S. Bureau of Reclamation 2023-2024)

7.5.1.3.11. XT Model

The XT model is a reconfiguration of the National Marine Fisheries Service Comprehensive Passage (NMFS COMPASS) smolt passage model, developed for Columbia River salmon and steelhead (Zabel et al. 2008). For each river reach, water velocity is determined with a power curve relationship between flow and velocity in a free-flowing reach. Fish passage time is a function of water velocity from which survival may be inferred from the distance traveled and travel time to complete that distance. Specifically, flow varies spatially and temporally such that there is a trade-off between the distance (X) a fish travels and the time spent (T) for a fish in a reach when calculating survival. The survival sub-model is calibrated from acoustically tagged fall-run Chinook salmon (Steel et al. 2020).

XT model applications in this consultation primarily focus on survival in the main stem Sacramento River, from Red Bluff Diversion Dam to the confluence with the American River upstream of the Delta. However, model runs also include survival (Figure 142) and travel time estimates (Figure 143) from Red Bluff Diversion Dam to the Delta Cross Channel, which include the river reaches of the north Delta. Those model runs show very small differences between the proposed action and the other modeling scenarios considered across most water year types except the dry and critical year types where there is increasing variance in the predicted survival with a drier hydrology. This indicates that migration survival, in the main stem Sacramento River from Red Bluff Diversion Dam to the Delta Cross Channel, is influenced by project operations but mostly during the drier years. Likewise, wetter years generally have higher survival compared to the drier years.

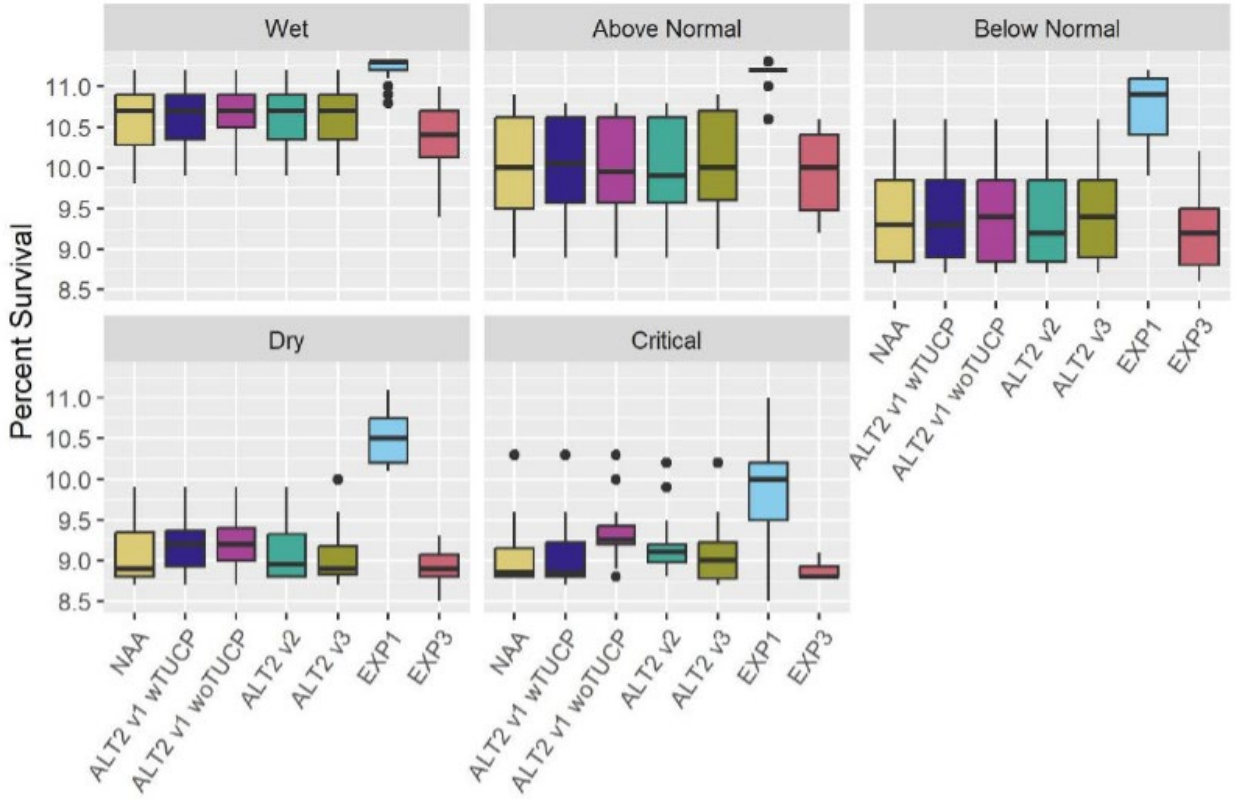


Figure 142. Boxplots of modeled mean survival between Red Bluff Diversion Dam and the Delta Cross Channel all modeled scenarios by water year type.

Source: Appendix J - Spring Delta Outflow Attachment J, XT Model in (U.S. Bureau of Reclamation 2023-2024)

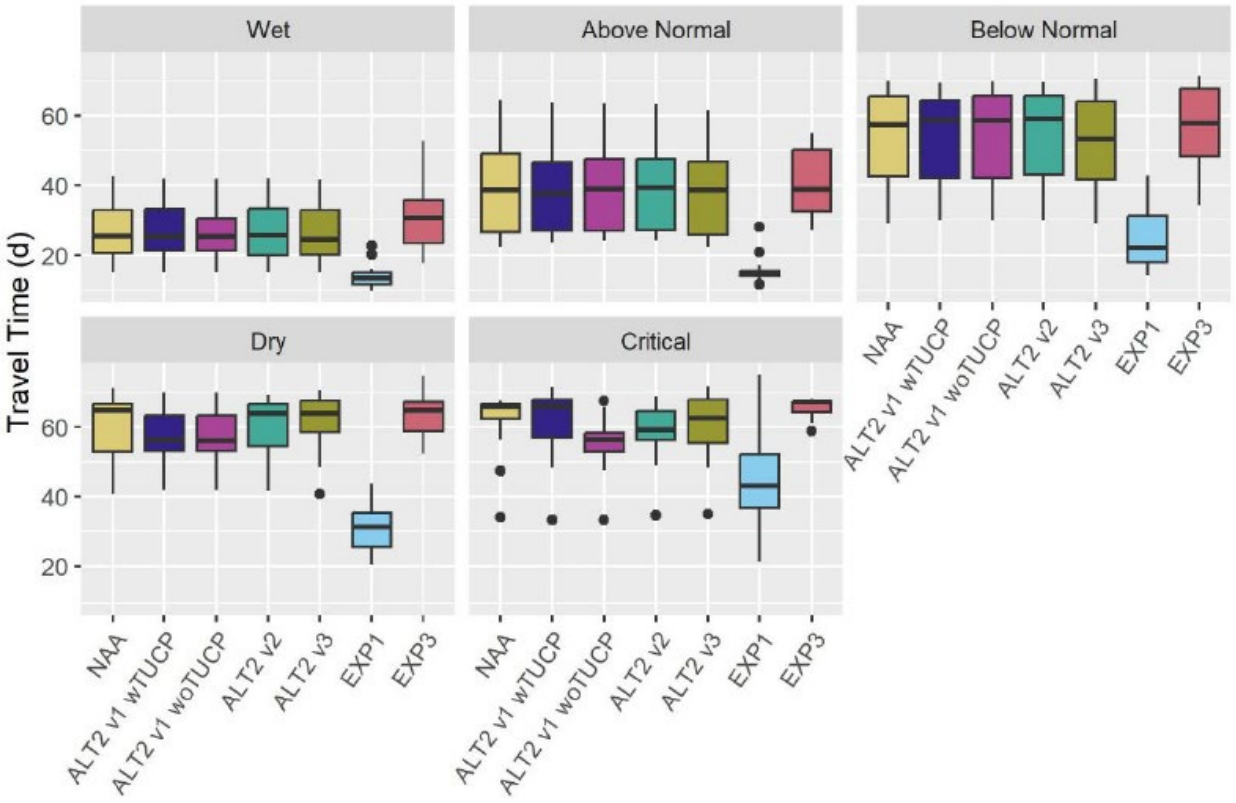


Figure 143. Boxplots of modeled mean travel time (days) between Red Bluff Diversion Dam and the Delta Cross Channel for all modeled scenarios by water year type.

Source: Appendix J - Spring Delta Outflow Attachment J, XT Model in (U.S. Bureau of Reclamation 2023-2024)

7.5.1.3.12. Sturgeon Year Class Index and Delta Outflow

The sturgeon year class index (YCI) and Delta outflow analysis assesses the potential effects of the proposed action on white or green sturgeon year-class strength (i.e., YCI) using the correlative relationship between Delta outflow and white sturgeon YCI described by Fish (2010). Using historical Delta outflow and white sturgeon YCI data to establish the relationships, modeled Delta outflow values from CalSim 3 are then used to estimate white sturgeon YCI. White sturgeon YCI is used as a surrogate to estimate green sturgeon YCI.

The primary assumption of the sturgeon YCI and Delta outflow analysis is that the correlation between white sturgeon YCI and Delta outflow is causal, such that Delta outflow drives white sturgeon YCI. Although this assumption of causality is reasonable, there is little evidence that Delta outflow itself drives the YCI. Just as likely, the two variables of Delta outflow and white sturgeon YCI may co-vary in response to another variable. Another assumption of this analysis is that white sturgeon is an appropriate surrogate species for green sturgeon.

Table 116 summarizes the white sturgeon YCI (surrogate for green sturgeon) by water year type for the various modeling scenarios considered.

Table 116. Year-Class Strength of White Sturgeon (Surrogate for Green Sturgeon) Based on March–July Regression with Delta Outflow.

Water Year Type	Proposed Action Alt2v2	Proposed Action Alt2v1	NAA	EXP3
Wet	48.3	47.9	48.9	90.0
Above Normal	6.5	6.3	6.7	9.9
Below Normal	2.9	2.8	2.9	3.8
Dry	2.0	1.9	2.0	2.3
Critical	1.3	1.2	1.2	1.4
All	16.6	16.3	16.7	29.7

Source: (Appendix J_Attachment J - Sturgeon YCI vs Outflow in (U.S. Bureau of Reclamation 2023-2024)

7.5.1.4. Seasonal Operations

In the winter and spring, Reclamation and DWR typically export excess water. Excess water conditions occur when releases from upstream reservoirs plus unregulated flow exceed Sacramento Valley in-basin uses and exports. Actions to minimize the entrainment of listed fish into the South Delta and at the Jones and Banks pumping plants limit the export of excess water through OMR management. Exports during the winter and spring reduce the reliance on conveying previously stored water in the summer and fall for south-of-Delta water supply needs. In dry conditions, Reclamation and DWR may need to increase releases from upstream reservoirs beyond what is needed to meet minimum flow requirements in order to meet water quality or outflow requirements in the Delta. Delta Cross Channel closures through the winter and spring months protect out-migrating salmonids from entering the interior Delta. Reclamation and DWR also take action during the spring to manage Delta outflow.

During the summer, the CVP and SWP convey previously stored water through the Delta for export at the Jones Pumping Plant, Banks Pumping Plant, and other Delta facilities. Delta operations during the summer typically focus on maintaining salinity and meeting Delta outflow objectives while maximizing exports with the available water supply. In addition, the CVP and SWP make upstream reservoir releases for water temperature management and instream flows, which may be available for export after outflow, salinity, and in-Delta needs have been met. Agricultural barriers may be installed in the South Delta to maintain water levels for south of Delta agricultural water diverters.

In the fall, operations are adjusted to meet salinity requirements, Delta outflow requirements, and peak demands from CVPIA wildlife refuges. Upstream and in-Delta demands typically decrease, and accretions within the system typically increase. When water is available and not required for salinity and Delta outflow requirements, late summer and fall provide an opportunity to export water and start filling San Luis Reservoir for the next water year. When conditions are dry, there is little opportunity for exports. Releases from upstream reservoirs generally decrease to

conserve water in storage for the next year. On occasion, releases to provide flood storage or protect existing redds may occur and result in additional flows into the Delta. Delta Cross Channel closures in late fall months can reduce the straying of Mokelumne River fall-run Chinook salmon and manage water quality per D-1641.

The Banks Pumping Plant pumps water from Clifton Court Forebay (CCF). The CCF radial gates are closed during critical periods of the ebb and flood tidal cycle for water quality and water levels in the South Delta. During July through September, the maximum daily diversion limit from the Delta into the CCF is increased from 6,990 cfs to 7,490 cfs, and the maximum average diversion limit over any 3 days is increased from 6,680 cfs to 7,180 cfs. From mid-December through mid-March, diversions into CCF may be increased by one-third of the San Joaquin River flow at Vernalis when those flows exceed 1,000 cfs. Furthermore, Banks Pumping Plant will pump up to 195,000 acre-feet for the CVP in accordance with the 2018 Coordinated Operations Agreement Addendum.

Reclamation and DWR also manage fish collection and salvage facilities to address fish entrainment at the export facilities 24 hours a day, 365 days per year, unless maintenance and repair actions demand a temporary disruption of operations. Aquatic weed management may be needed year-round to prevent damage to SWP equipment and reduce refugia for invasive predatory fish species.

Operation of the Delta Cross Channel changes by season. During the summer and early fall, the Delta Cross Channel is operated to improve the movement of water from the Sacramento River to the export facilities at the Jones and Banks pumping plants; improve water quality in the Central and South Delta; reduce salinity intrusion rates in the west Delta; and allow passage for boaters. Reclamation closes the Delta Cross Channel during the late fall, winter, and spring to reduce straying of Mokelumne River fall-run Chinook salmon, protect out-migrating salmonids from entering the interior Delta, and facilitate the State Water Board D-1641 Rio Vista flow objectives for fish passage.

For the Bay-Delta Division water operations, there are three main agency coordination forums that will meet regularly to discuss seasonal and real-time operations. These include the WOMT, the Smelt Monitoring Team, and the Salmonid Monitoring Team (SaMT). The WOMT is a policy level group that discusses the operations actions in the Bay-Delta Division, American River Division, and the Stanislaus/East Side Division. The Smelt Monitoring Team is a technical group that discusses Delta Operations and smelt protections. The SaMT is a technical group that discusses Delta Operations and salmon and steelhead protections. The WOMT will coordinate regularly with SHOT and other work groups as appropriate. Delta Governance will use a collaborative approach to planning and decision-making. Governance describes that the groups will strive to reach consensus; if consensus cannot be reached, group members may elevate to the next higher level for resolution. Agency directors may reserve final decision making for matters under their respective authority.

7.5.1.5. Delta Cross Channel Gate Closures (and Maintenance and Repair)

Reclamation opens the Delta Cross Channel to improve the movement of water from the Sacramento River to the export facilities at the Jones and Banks pumping plants, improve water

quality in the Central and South Delta, reduce salinity intrusion rates in the west Delta, and allow passage for boaters. Reclamation closes the Delta Cross Channel during the late fall, winter, and spring to reduce straying of Mokelumne River fall-run Chinook salmon (not an ESA-listed species), protect out-migrating salmonids from entering the interior Delta, facilitate the State Water Board D-1641 Rio Vista flow objectives for fish passage, and reduce potential scouring and flooding that might occur in the channels on the downstream side of the gates when Sacramento River flows exceed 20,000 cfs on a sustained basis.

Operation of the Delta Cross Channel gates can influence downstream migration by providing false migration cues for juvenile and adult salmon, steelhead, and sturgeon to move from the Lower Sacramento River into the Central Delta rather than their intended destination of the western Delta and San Francisco Bay. The Delta Cross Channel Gate Closure action addresses the out-migration cues and entrainment risk stressors for salmon and steelhead.

Delta Cross Channel closure will continue to occur as follows:

October 1–November 30, Catch Index Closures

From October 1 through November 30, Reclamation proposes to close the Delta Cross Channel gates in addition to the requirements in D-1641 to further reduce juvenile salmonid entrainment risk based on the Knights Landing Catch Index and Sacramento Catch Index as described in

Table 117. Observations of daily increases in catch indices are typically associated with increased flows at Wilkins Slough and tributaries to the Upper Sacramento River, cooler water temperatures at these locations, and entry of migrating juvenile SR winter-run and CV spring-run Chinook salmon (Low and White 2006, del Rosario et al. 2013).

Table 117. Delta Cross Channel action triggers and responses during Lower Mokelumne River flow releases.

Action Trigger	Action Response
• Water quality criteria per D-1641 are met; and • Knights Landing Catch Index or Sacramento Catch Index (daily index) ≥ 3.0	Within 48 hours of index being reported to Reclamation, close the Delta Cross Channel gates for at least 3 days and keep closed until the catch index is less than three fish per day at both the Knights Landing and Sacramento monitoring sites for 2 consecutive days.
• Water quality criteria per D-1641 are met; and • Knights Landing Catch Index or Sacramento Catch Index (daily index) ≥ 3.0; and • Real time hydrodynamic and salinity modeling shows water quality levels of concern (criteria as presented in Table 118) are exceeded during 14- day period following Delta Cross Channel closure	Reclamation and DWR, through Delta Monitoring Teams, review monitoring data and complete risk assessment to inform real-time operations of Delta Cross Channel gate closure.
• Water quality criteria are not met per D-1641 criteria	No Delta Cross Channel gate closure.

Table 118. Water quality levels of concern (simulated 14-day average electrical conductivity).

Station	Water Quality Concern Level (micromhos per centimeter)
Jersey Point	1800
Bethel Island	1000
Holland Cut	800
Bacon Island	700

October 1–November 30, Lower Mokelumne River Fall Closure

From October 1 through November 30, Reclamation proposes to close the Delta Cross Channel gates in addition to the requirements in D-1641 to enhance adult fall-run Chinook salmon passage into the Mokelumne River as described in Table 119. If the East Bay Municipal Utility District releases Lower Mokelumne River attraction flows, water quality modeling shows concern level criteria (Table 118) are not likely to be exceeded for at least 14 days following the action, and there is no observed deterioration of interior Delta water quality, then Reclamation would close the Delta Cross Channel gates as soon as practicable (generally within 48 hours) for up to 5 days. Closure of the Delta Cross Channel gates when adult fall-run Chinook salmon attraction flows pass through the Lower Mokelumne River can reduce straying of Chinook salmon between the Mokelumne and American rivers and increase the abundance of fall-run Chinook salmon returning to the Mokelumne River and its hatchery.

Table 119. Delta Cross Channel action triggers and responses during Lower Mokelumne River flow releases.

Action Triggers	Action Responses
• Water quality criteria per D-1641 are met; and • Real-time hydrodynamic and salinity modeling shows water quality concern level targets (Table 118) are not exceeded during 14-day period following Delta Cross Channel closure; and • There is no observed deterioration of interior Delta water quality	Within 48 hours of the start of Lower Mokelumne River attraction flow release, close the Delta Cross Channel gates for up to 5 days.
• Water quality criteria per D-1641 are met; and • Real time hydrodynamic and salinity modeling shows water quality concern level targets (Table 118) are exceeded during 14-day period following Delta Cross Channel closure	Reclamation and DWR, through Delta Monitoring Teams, review monitoring data and complete risk assessment to inform real-time operations of Delta Cross Channel gate closure.
• Water quality criteria are not met per D-1641	No Delta Cross Channel gate closure.

December 1–January 31

From December 1 to January 31, Reclamation proposes to close the Delta Cross Channel gates, except to avoid exceeding a D-1641 water quality criterion within the next 14 days based on

water quality modeling (rather than increase releases and reduce reservoir storage further). Reclamation and DWR will prepare an assessment to evaluate opening the Delta Cross Channel gates for up to 5 days for up to two events within this period to avoid D-1641 water quality criteria exceedance. Reclamation and DWR will coordinate with USFWS, NMFS, CDFW, and the SWRCB on how to balance D-1641 water quality and ESA-listed fish requirements and inform the SaMT and Smelt Monitoring Team. The assessment will consider relevant monitoring information (e.g., upstream rotary screw traps, Delta juvenile fish monitoring surveys, Rio Vista flow standards, and acoustic telemetered fish monitoring information) as well as potentially DSM2 modeling informed with recent hydrology, salinity, and tidal data. During these potential Delta Cross Channel gate openings, the CVP and SWP will limit combined exports so as not to exceed the 1,500 cfs Health and Safety pumping level.

February 1–May 20

Reclamation will keep the Delta Cross Channel gates closed. State Water Board D-1641 requires the Delta Cross Channel Gates to be closed.

May 21–June 15

Reclamation will close the Delta Cross Channel gates for a total of 14 days. Reclamation and DWR, through SaMT, will prepare a plan that considers relevant information including: the upstream rotary screw traps, Delta juvenile fish surveys, Rio Vista flow standards, acoustic telemetered fish information, and DSM2 modeling. Reclamation typically schedules the Delta Cross Channel closures to occur on weekdays and keeps it open on weekends to accommodate recreational interests. State Water Board D-1641 requires the Delta Cross Channel to be closed for a total of 14 days after consultation with the USFWS, CDFW, and NMFS.

June 16–September 30

From June 16 to September 30, Reclamation proposes to open the Delta Cross Channel gates.

Maintenance and Repair

The Reclamation Designers Operating Criteria, dated September 24, 1971, requires Reclamation to undertake routine maintenance and repair of the Delta Cross Channel gates to continue reliable operation. Certain routine maintenance and repairs require cycling of one or both Delta Cross Channel gates (i.e., open and close the gates several times in a row) approximately twice per year for 1 day each. Reclamation is required to maintain the Delta Cross Channel gates and may not have discretion over when the maintenance must occur. To avoid and minimize effects, Reclamation, to the extent practicable will:

- Perform cycling when federally-listed fish are not likely present (mid-June through September)
- Perform cycling during daylight hours and minimize the duration of the time Delta Cross Channel is open during cycling when salmonids are present
- Reclamation will notify USFWS and NMFS of maintenance prior to its implementation, if it occurs during a closure period

7.5.1.5.1. Species Exposure to Delta Cross Channel Operations & Maintenance

Species presence in the Delta is summarized generally in Section 7.5.1.2 Presence of the Species Within the Bay-Delta Division. This section discusses the more localized exposure of SR winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon to the five general operational periods for the Delta Cross Channel gates.

7.5.1.5.1.1. Sacramento River Winter-Run Chinook Salmon

The timing of observations of natural (i.e., non-clipped fish) juvenile SR winter-run Chinook salmon captured in the Sacramento Trawl (Sherwood Harbor) will serve as a proxy for their presence in the vicinity of the Delta Cross Channel gates (refer to Table 111 in Section 7.5.1.2 Presence of the Species Within the Bay-Delta Division).

For the period of October 1 to November 30, few natural juvenile SR winter-run Chinook salmon are observed in the catch of the Sacramento Trawl. On average, the date of the first observation of natural juvenile SR winter-run Chinook salmon for the period covering brood years 1999 to 2023 is December 9, and the median date of the first observation of natural SR winter-run Chinook salmon in the trawl for this period of time is December 6 (University of Washington Columbia Basin Research 2024a). The earliest date of the first appearance of natural SR winter-run Chinook salmon in the Sacramento Trawl is September 10 (brood year 2001), and the latest date for the first appearance of a natural juvenile SR winter-run Chinook salmon is March 3 (brood year 2016).

From December through March, approximately 50 percent of the natural juvenile SR winter-run Chinook salmon population has moved past the Sherwood Harbor location into the vicinity of the Delta Cross Channel gates. The average date for 50 percent passage is January 27, with the median date of February 11, for the period covering brood years 1999 to 2023.

During the period of February 1 to May 20, when the gates are closed, the remainder of the natural juvenile SR winter-run Chinook salmon cohort has passed through the Sherwood Harbor location. For the period covering brood years 1999 to 2023, the average last date of the observation of natural juvenile SR winter-run Chinook salmon in the trawl is March 28, with the median date of the last observation being slightly later, on April 5.

Typically, no observation of natural juvenile SR winter-run Chinook salmon occurs from May 21 to September 30.

Approximately 30 percent to 40 percent of these emigrating juveniles are expected to enter Sutter and Steamboat sloughs (Perry et al. 2010) and will avoid the location of the Delta Cross Channel gates. The majority of downstream emigrating fish (60 to 70 percent) are expected to stay in the main stem of the Sacramento River and encounter the location of the Delta Cross Channel gates during their downstream migration. Hatchery-produced SR winter-run Chinook salmon from the LSNFH are typically released into the Upper Sacramento River in early to mid-February and would arrive in the Delta after the Delta Cross Channel gates are closed for the period from February 1 through May 20.

Adult SR winter-run Chinook salmon are expected to start moving into the vicinity of the Delta Cross Channel gates starting in November and continue migrating past the Delta Cross Channel gate location through June, with a peak presence from February to April. A flow of 400 cubic meters per second (14,126 cfs) or more on the Sacramento River is associated with a spike in the catch of SR winter-run Chinook salmon at the Knights Landing rotary screw trap monitoring location (del Rosario et al. 2013). The first day that flows reached 400 cubic meters per second is nearly coincident with the day of catch spike (an increase of 5 percent of cumulative catch) and the day of median catch (50th percentile of cumulative catch).

Most adult SR winter-run Chinook salmon are expected to remain in the main channel of the Sacramento River during their upstream migration. However, some fish may use alternate routes to move upstream. These include the channels of Sutter and Steamboat sloughs to the north of the mainstem Sacramento River channel, which would avoid the location of the Delta Cross Channel gates, as well as channels from the south, such as Georgiana Slough, which reconnects with the mainstem Sacramento River downstream of the Delta Cross Channel gate location. During the period from November through January when adult SR winter-run Chinook salmon are expected to be migrating upriver, the gates may be either open or closed depending on water quality conditions and the presence of juvenile listed fish (SR winter-run Chinook salmon and yearling CV spring-run Chinook salmon). When the Delta Cross Channel gates are closed, any false attraction flows through the Delta Cross Channel into the Mokelumne River system will likely be minimized. Conversely, when the gates are open during this period of time, false attraction flows from the mainstem Sacramento River will flow into the Mokelumne River system and potentially attract adult SR winter-run Chinook salmon into the system from the San Joaquin River mainstem. From February 1 through May 20, the Delta Cross Channel gates are closed, and there should be no false attraction flows to encourage straying into the Mokelumne River system. From May 21 through the end of the adult SR winter-run Chinook salmon migration (June), the gates may be either closed or open. This may encourage straying in any late migrating adult SR winter-run Chinook salmon encountering the open gate condition.

While Reclamation plans to complete routine maintenance from mid-June through September, when no juvenile and very few adult SR winter-run Chinook salmon are expected to be present, the proposed action acknowledges that repairs could be necessary at any time. NMFS expects the frequency and duration of any SR winter-run Chinook salmon exposure to maintenance or repair-related gate openings to be infrequent and short, lasting less than a few days per year and limited to daylight hours to minimize disturbance to salmon.

7.5.1.5.1.2. Central Valley Spring-Run Chinook Salmon

The timing of observations of natural juvenile young-of-the-year CV spring-run Chinook salmon captured in the Sacramento Trawl (Sherwood Harbor) will serve as a proxy for their presence in the vicinity of the Delta Cross Channel gates (refer to Table 111 in Section 7.5.1.2 Presence of the Species Within the Bay-Delta Division).

For the period of October 1 to November 30, very few natural young-of-the-year CV spring-run Chinook salmon juveniles are observed in the catch of the Sacramento Trawl. On average, the date of the first observation of threatened natural young-of-the-year juvenile CV spring-run

Chinook salmon for the period covering brood years 1999 to 2022 is January 3, and the median date of the first observation of CV spring-run Chinook salmon in the trawl for this period of time is December 29 (University of Washington Columbia Basin Research 2024a). The earliest date of the first appearance of a natural young-of-the-year CV spring-run Chinook salmon in the Sacramento Trawl is November 23 (2016, a below-normal year), and the latest date for the first appearance of a natural young-of-the-year CV spring-run Chinook salmon juvenile is February 23 (2008, a critically dry year).

From December 1 through January 31, less than 5 percent of the natural young-of-the-year juvenile CV spring-run Chinook salmon population has moved past the Sherwood Harbor location into the vicinity of the Delta Cross Channel gates. The average and median date for 50 percent passage is April 11 for the period covering brood years 1999 to 2022.

During the period of February 1 to May 20, when the gates are closed, nearly all of the remaining young-of-the-year juvenile CV spring-run Chinook salmon population has passed through the Sherwood Harbor location, with very few individuals observed after May 20. On average, by April 28, 95 percent of the juvenile CV spring-run Chinook salmon population has moved past the Sherwood Harbor trawl location. The average date of the last observation of natural young-of-the-year juvenile CV spring-run Chinook salmon in the trawl is May 12, with the median date of the last observation being May 11. Historically, very few natural young-of-the-year juvenile CV spring-run Chinook salmon are observed in the trawl during the period of May 21 to June 15 and essentially none from June 16 to September 30.

Hatchery-produced CV spring-run Chinook salmon from the FRFH are typically released in the spring in March and April and normally would encounter the Delta Cross Channel gates when they are closed. If fish are slow in migrating downstream from their upstream releases, they may encounter the gates when they are opened periodically between May 21 and June 15.

An alternate life history strategy for CV spring-run Chinook salmon is to emigrate as yearlings during the fall and early winter after oversummering in rivers and streams upstream of the Delta where conditions are suitable for their survival (i.e., Mill Creek, Deer Creek, and other Sacramento River tributaries supporting spring-run spawning). Typically, these fish emigrate as much larger fish than juvenile young-of-the-year CV spring-run Chinook salmon and are thus less likely to be observed in the trawls and other monitoring actions due to their ability to avoid them. Yearling CV spring-run Chinook salmon are expected to enter the Delta after precipitation events in the Upper Sacramento River basin increase flows in the tributaries and the mainstem Sacramento River and stimulate the yearling CV spring-run Chinook salmon to start emigrating downstream. This may occur as early as October and extends through January and February. These fish would likely encounter the open Delta Cross Channel gates prior to December 1 and any time the gates are opened from December 1 through January 31 for water quality issues.

Of the fish moving downstream in the mainstem Sacramento River, approximately 30 to 40 percent of these emigrating juveniles are expected to enter Sutter and Steamboat sloughs (Perry et al. 2010) and will avoid the location of the Delta Cross Channel gates. The majority of downstream emigrating fish (60 to 70 percent) are expected to stay in the main stem of the

Sacramento River and encounter the location of the Delta Cross Channel gates during their downstream migration.

Adult CV spring-run Chinook salmon in the Sacramento River are expected to start moving into the vicinity of the Delta Cross Channel gates in January and continue migrating past the Delta Cross Channel gate location through June, with a peak presence from February to April. Adult CV spring-run Chinook salmon are expected to encounter the Delta Cross Channel gates in a similar fashion and timing to that already described for adult SR winter-run Chinook salmon.

While Reclamation plans to complete routine maintenance from mid-June through September, when no juvenile and very few adult CV spring-run Chinook salmon are expected to be present, the proposed action acknowledges that repairs could be necessary at any time. NMFS expects the frequency and duration of any CV spring-run Chinook salmon exposure to maintenance or repair-related gate openings to be infrequent and short, lasting less than a few days per year and limited to daylight hours to minimize disturbance to salmon.

7.5.1.5.1.3. California Central Valley Steelhead

The timing of observations of natural juvenile CCV steelhead captured in the Sacramento Trawl (Sherwood Harbor) will serve as a proxy for their presence in the vicinity of the Delta Cross Channel gates (refer to Table 111 in Section 7.5.1.2 Presence of the Species Within the Bay-Delta Division).

For the period of October 1 to November 30, very few juvenile CCV steelhead have been observed in the catch of the Sacramento Trawl. On average, the date of the first observation of juvenile CCV steelhead for the period covering brood years 1999 to 2023 is February 16, and the median date of the first observation of CCV steelhead in the trawl for this period of time is February 8 (University of Washington Columbia Basin Research 2024a). The earliest date of the first appearance of CCV steelhead in the Sacramento Trawl is January 11 (2008, a critical year), and the latest date for the first appearance of a CCV steelhead juvenile is May 10 (2011, a wet year); however, there were only two fish reported at the Sacramento Trawl in 2011.

From December 1 through January 31, less than 10 percent of the natural juvenile CCV steelhead population has moved past the Sherwood Harbor location into the vicinity of the Delta Cross Channel gates. The average date for 50 percent passage is March 14, for the period covering brood years 1999 to 2023. The median date for 50 percent passage is March 16.

During the period of February 1 to May 20, when the gates are closed, most of the juvenile CCV steelhead population has passed through the Sherwood Harbor location. On average, by May 27, 95 percent of the juvenile CCV steelhead population has moved past the Sherwood Harbor trawl location. The average date of the last observation of juvenile CCV steelhead in the trawl is May 27, with the median date of the last observation on May 24. Historically, very few juvenile CCV steelhead are observed in the trawl during the period of May 21 to June 15, and in recent years, none have been observed from June 16 to September 30.

Hatchery-produced CCV steelhead are typically released in January and February but may be released as early as mid-December and as late as April and May. Therefore, hatchery CCV

steelhead may encounter the Delta Cross Channel gates if they are opened in December or January for water quality issues.

Using the assumption that juvenile CCV steelhead will distribute into different river channels in a similar proportion as do juvenile Chinook salmon, approximately 30 to 40 percent of these emigrating juvenile CCV steelhead are expected to enter Sutter and Steamboat sloughs (Perry et al. 2010) and will avoid the location of the Delta Cross Channel gates. The majority of downstream emigrating fish (60 to 70 percent) are expected to stay in the main stem of the Sacramento River and encounter the location of the Delta Cross Channel gates during their downstream migration.

Adult CCV steelhead begin to migrate through the Lower Sacramento River starting in July and continue through late fall, with a secondary peak occurring in late spring (presumably adults returning downstream as kelts). For most of the upstream migratory period, 90 percent of the adult CCV steelhead will encounter the Delta Cross Channel gates when they are open (July through November). From December through January, an additional 5.5 percent of migrating adults will encounter the gates in a primarily closed position but may also encounter them in an open position if water quality is a concern. Less than 5 percent of the population will migrate during the February 1 through May 20 period when the gates are closed and the May 21 through June 15 periods when the gates are typically closed half of the time.

Reclamation plans to complete routine maintenance from mid-June through September, when both juvenile and adult CCV steelhead may be present, and acknowledges that repairs could be necessary at any time (for example during the winter and spring, when juvenile CCV steelhead are more abundant compared to the summer months. NMFS expects the frequency and duration of any CCV steelhead exposure to maintenance or repair-related gate openings to be infrequent and short, lasting less than a few days per year and limited to daylight hours to minimize disturbance to CCV steelhead.

7.5.1.5.1.4. Southern Distinct Population Segment of Green Sturgeon

Both adult and juvenile sDPS green sturgeon are expected to be within the waters of the Delta year-round. Individual sDPS green sturgeon may encounter the Delta Cross Channel gates in multiple configurations as fish may hold and rear near the gates or encounter it as they move upstream and downstream during their behavioral movements. Adult sDPS green sturgeon are likely to encounter closed Delta Cross Channel gates during their upstream spawning migration in winter and early spring, but encounter open gates during their downstream migration in summer and fall following spawning. Juvenile sDPS green sturgeon rearing in the Delta may encounter the gates year-round in an open position (typically mid-June through September), intermittently closed (October and November), or in a closed position (December through mid-May).

The multi-agency SAIL synthesis teams also identified the relevant pathways by which entrainment is likely to affect species, as well as how it is likely to interact with other stressors. Windell et al. (2017) note survival across all life stages and in all geographic regions can be affected by entrainment, particularly within the rearing to out-migrating juvenile stage in the upper and middle Sacramento River and in the Delta.

Reclamation plans to complete routine maintenance mid-June through September and acknowledges that repairs could be necessary at any time. Juveniles and adults of sDPS green sturgeon may be present in the Delta throughout the year. NMFS expects the frequency and duration of any sDPS green sturgeon exposure to maintenance or repair-related gate openings to be infrequent and short, lasting less than a few days per year and limited to daylight hours to minimize disturbance to sDPS green sturgeon.

7.5.1.5.2. Response of Species Exposed to the Proposed Delta Cross Channel Gate Operations

The Delta Cross Channel can divert a significant proportion of the Sacramento River's water into the interior of the Delta, and operations of the gates create complex hydrodynamic interactions as a result. Operations of the Delta Cross Channel gates create the following stressors related to changes in water flow, exposure to predation, and increased risk of straying or delayed migration:

- Fish routing into various migratory pathways
- Alterations to transit times related to routing and alterations in flow (Horn and Blake 2004)
- Increased risk to predation due to routing and increased transit times
- Increased risk to entrainment at the CVP and SWP export facilities
- Creation of false attractant flows through the open Delta Cross Channel gates

7.5.1.5.2.1. Routing

When the Delta Cross Channel gates are open, juvenile fish moving within the mainstem of the Sacramento River adjacent to the Delta Cross Channel junction may be entrained into the open channel and pass downstream into the Mokelumne River system and subsequently into the waterways of the interior Delta. Numerous acoustic tagging studies have confirmed that when the gates are open, a substantial proportion of juvenile fish are routed into the Delta Cross Channel (Newman and Brandes 2010, Perry et al. 2010, Perry et al. 2012, Romine et al. 2013).

The proportion of acoustically-tagged Chinook salmon entrained into the Delta interior varied over the years. Perry et al. (2010) found that for studies in 2006 and 2007, when the Delta Cross Channel gates were open, 38.7 percent of the fish present in the mainstem Sacramento River at the Delta Cross Channel junction (the 60 to 70 percent that were left in the mainstem Sacramento River downstream of Sutter and Steamboat Slough junctions) were entrained into the Delta Cross Channel and 16.1 percent were entrained into Georgiana Slough. When the Delta Cross Channel gates were closed, 15 to 20 percent of the fish in the Sacramento River present at the Georgiana Slough junction were entrained into the Georgiana Slough route. Of the fish that were not entrained into the interior Delta, 45.2 percent remained in the Sacramento River when the Delta Cross Channel gates were open, and nearly twice that percentage (80.0 to 85.0 percent) remained in the mainstem of the Sacramento River when the Delta Cross Channel gates were closed. For studies conducted in 2008–2009, Romine et al. (2013) reported that the percentage of fish entering the Delta Cross Channel junction from the Sacramento River when the gates were open ranged between 13.6 and 66.7 percent, with an overall average of 47 percent. For studies conducted in 2009–2010, Perry et al. (2012) reported that of fish present in the Sacramento

River/Delta Cross Channel junction when the gates were open, 20 percent of those fish entered the Delta Cross Channel, consistent with previous studies in 2007–2008. When the Delta Cross Channel gates are closed, more fish are entrained into the Georgiana Slough route because more fish remain in the Sacramento River mainstem past the Delta Cross Channel junction. However, the proportion of fish that remain in the Sacramento River below both junctions (Delta Cross Channel and Georgiana Slough) into the interior Delta typically increases when the Delta Cross Channel gates are closed.

7.5.1.5.2.2. Transit Times

Fish that enter the interior Delta through the open Delta Cross Channel gates or Georgiana Slough will have a longer migratory route than fish that emigrate through either the mainstem Sacramento River or Sutter and Steamboat sloughs. Longer migratory routes would be expected to have lower survival rates in part due to longer transit times to the western Delta (Chipps Island), exposure to the effects of the export facilities in the southern Delta, and a prolonged exposure period to predators along these migratory routes. Perry et al. (2012) examined survival rates for unit distance traveled in the Delta and indicated that the mortality rate per kilometer traveled actually increased as fish traveled from the upper Delta to the lower Delta, becoming the greatest in the tidal zone. The greatest decline in survival was observed for fish entering the interior Delta and traveling through the mainstem San Joaquin River from the mouth of the Georgiana Slough/Mokelumne River complex to Chipps Island, a region of increased tidal influence.

NMFS expects that environmental conditions that would require the opening of the Delta Cross Channel gates during the November through January period of juvenile Chinook salmon and CCV steelhead emigration would be associated with lower river inflows from the Sacramento River and San Joaquin River, leading to the reduced water quality conditions that would necessitate the gate openings. Low water flow in the mainstem Sacramento River would increase transit times within the region's channels leading to the Delta Cross Channel junction. Opening the gates would allow fish to enter the Delta interior under low flow conditions, leading to a longer migratory route with increased transit times and lower survival. It would also exacerbate the transit times for fish remaining in the mainstem Sacramento River due to a smaller volume of water and slower flows remaining in that channel after passing the Delta Cross Channel junction with the open gates. The reduction in flow in the mainstem Sacramento River coupled with the open Delta Cross Channel gates would alter the local hydrodynamics surrounding the junctions of the Delta Cross Channel and Georgiana Slough, potentially leading to higher cumulative levels of entrainment into the Delta interior with the associated lower levels of survival for salmonids (Perry et al. 2015, Plumb et al. 2016). These changes in local hydrodynamics are discussed below.

7.5.1.5.2.3. Influence of Local Hydrodynamics Related to Flow

Perry et al. (2015) and Plumb et al. (2016) found that there is a tidal-flow threshold for entrainment into the interior Delta. When flows in the Sacramento River upstream of the Delta Cross Channel junction were less than approximately 12,000 cfs, flood tides caused the lower portions of the Sacramento River, including the location of the Delta Cross Channel, to reverse

direction during flood tides, but not at flows above this threshold. Reverse flows during flood tides increased the amount of flow entering the Delta Cross Channel and the probability of fish being entrained into the Delta interior via that route. Fish that arrived at the Delta Cross Channel junction during ebb tides had a lower entrainment probability into the Delta Cross Channel route. In contrast, fish that arrived during flood tides with flow reversal had a high probability of entrainment into the Delta interior via the open Delta Cross Channel gates. Perry et al. (2018) modeled the interacting influences of river flows and tides on travel time, routing, and survival of juvenile late-fall-run Chinook salmon migrating through the Delta. Their modeling found that travel time was inversely related to river inflows in all river reaches examined. Survival was positively related to river inflow only in the reaches that transitioned from bidirectional (tidal) to unidirectional (riverine) with increasing river inflows. The researchers also found that the probability of entering alternative routes to the interior Delta declined with increasing river inflows. Thus, by keeping river flows elevated in the mainstem of the Sacramento River, such as by keeping the Delta Cross Channel gates closed, tidal fluctuations downstream of the junction are dampened in all but the most tidal reaches. Perry et al. (2018) found evidence that opening the Delta Cross Channel gates, which removes water from the Sacramento River channel, was associated with lower survival in the reaches of the Sacramento River downstream of the Delta Cross Channel junction. In addition, the modeling showed that as flow in the mainstem Sacramento River increases, the probability of entering Georgiana Slough when the Delta Cross Channel gates are closed decreased by 16 percent. Likewise, an open Delta Cross Channel gate reduces the percentage of fish entering Georgiana Slough, but this is in part due to fewer fish being present at the Georgiana Slough junction to be entrained, since there is an increased percentage of fish that went into the Delta Cross Channel route through the open gates and into the interior Delta. The cumulative percentage of fish that are entrained into the Delta interior (Delta Cross Channel plus Georgiana Slough) was 15 percent higher than the probability of entering Georgiana Slough alone when the gates are closed.

7.5.1.5.2.4. Survival Related to Transit Routes and Predator Exposure

Perry et al. (2012), Perry et al. (2010), Perry et al. (2013), and Romine et al. (2013) have stated that survival is lowest for Chinook salmon entrained into the Delta interior. The interior Delta routes are longer than the routes using the Sacramento River or Sutter/Steamboat sloughs and, therefore, would expose migrating Chinook salmon to more predation risk than shorter routes (Perry et al. 2012). Cumulative survival over a given route is a product of migration distance or migration rate and mortality per unit distance and interacts to affect total survival for each route. The acoustic tag studies by Perry et al. (2012) and Perry et al. (2018) found that the interior Delta routes are longer and had a higher mortality rate per unit distance traveled than other routes through the Delta. This finding indicates that even if the migration routes through the Delta interior were the same distance as other routes, overall survival would still be less due to the higher mortality rate per unit distance. Higher mortality rates per unit distance combined with longer migration distance provides one mechanism for explaining the consistently lower survival for fish entering the interior Delta relative to the Sacramento River. In a tidal environment, where prey migration speeds are likely slower relative to predator swimming speeds, such that multiple encounters with predators are possible, the probability of survival depends on travel time through the reach and not necessarily the distance traveled. In the tidal reaches of the Delta, salmon movement patterns shift from downstream-only directed movements to both upstream

and downstream movements. Thus, in the lower reaches of the Delta, a fish may pass through a given reach more than once as they move upstream with the flood tide and then back downstream on the ebb tide, increasing not only the time it takes to move through this reach, but also increasing the absolute distance traveled. This could increase the number of predator encounters relative to the reach length, increasing mortality rates per unit distance traveled.

In addition, as fish are moved back and forth in a given tidally influenced river channel reach, they may be exposed multiple times to any waterway junctions within a given reach. With each passage past the junction, the probability of routing into the alternate route increases. If that route leads into a habitat that has less survival potential, such as the interior Delta via Georgiana Slough, the overall survival probability for that individual fish is reduced, and hence the overall survival fraction of the population may be reduced with each additional individual that is routed into the less favorable migratory route. There have been recent efforts to test alternative technologies to create non-physical and physical barriers at such junctions that dissuade movement into those junctions (California Department of Water Resources 2012, 2015, 2016). DWR has tested a bioacoustics barrier and a floating fish guidance structure in the Georgiana Slough junction with the mainstem Sacramento River under various flow conditions. Results indicated that at certain flow ranges, the barriers could be effective at keeping emigrating salmonids in the main stem of the Sacramento River and reducing the fraction that could enter the Georgiana Slough route.

7.5.1.5.2.5. Increased Risk of Entrainment at the Central Valley Project and State Water Project Fish Salvage Facilities

Salmonids that are entrained through the open Delta Cross Channel gates and into the Delta interior also have a greater probability of eventually being entrained at the SWP and CVP fish salvage facilities (Low and White 2006, Newman and Brandes 2010) than fish that remain in the Sacramento River migratory route. Fish that exit from the downstream end of the Delta Cross Channel routes through the Delta interior enter the tidally influenced Lower San Joaquin River mainstem. Tidal forcing can redirect fish into the channels of OMR, where the influence of the exports is manifested as net reverse flows towards the export facilities.

7.5.1.5.2.6. Increased Risks of Straying or Delayed Migration Due to Delta Cross Channel Gate Operations

In situations where the Delta Cross Channel gates are open, additional flows from the Sacramento River enter the Delta interior via the Mokelumne River system. Flows from the Sacramento River into this waterway system may provide false olfactory cues for adult Chinook salmon, CCV steelhead, and sDPS green sturgeon. Acoustic tracking studies by CDFG (CALFED Bay-Delta Program 2001) indicated that adult fall-run Chinook salmon may make extensive circuitous migrations through the Delta before finally ascending either the Sacramento River or San Joaquin River to spawn. These movements included “false” runs up the mainstems with subsequent returns downstream into the Delta before their final upriver ascent. Tagged fish moved up to the location of the Delta Cross Channel gates and either passed through the open gates or were blocked by closed gates, forcing them to return downstream and find another route to the mainstem Sacramento River to continue their upstream migration.

7.5.1.5.3. Summary of Delta Cross Channel Gate Closures (and Maintenance and Repair) Effects to Individuals

7.5.1.5.3.1. Sacramento River Winter-Run Chinook Salmon

Juvenile SR winter-run Chinook salmon in the Sacramento River can start migrating into the vicinity of the Delta Cross Channel gates starting as early as September or October based on the earliest dates for recorded captures in the Sacramento Trawl, but more typically are not observed until November. As indicated in the Presence of the Species Within the Bay-Delta Division section, the average first date of observation in the Sacramento Trawl is in late November or early December. During the October 1 to November 30 period, the Delta Cross Channel gates may be closed to protect pulses of early emigrating juvenile SR winter-run Chinook salmon if the Knights Landing catch index or Sacramento catch index triggers are exceeded. This typically occurs when the first major precipitation event occurs in the fall or early winter period and Sacramento River flow exceeds about 14,000 cfs at Wilkins Slough (del Rosario et al. 2013). This initial migration event has been shown to include over 50 percent of the annual SR winter-run Chinook salmon population sampled at Knights Landing (del Rosario et al. 2013). If flows exceed approximately 20,000 cfs at Freeport, then the Delta Cross Channel gates are closed for flood protection in downstream river reaches. This would also be protective of SR winter-run Chinook salmon or other listed salmonids moving downstream under the elevated flows. From December 1 through January 31, the Delta Cross Channel gates are normally closed, but may be opened for water quality concerns. By the end of January, typically 50 percent of the juvenile SR winter-run Chinook salmon for that year has entered the Delta and is in the vicinity of the Delta Cross Channel gates. Closure of the gates during this period will protect a substantial proportion of the cohort. If the gates are opened for water quality concerns, a substantial proportion of the juvenile SR winter-run Chinook salmon cohort may be at risk of entrainment into the Delta Cross Channel waterway for the less than 1 in 10 years that the gates are expected to be open between December 1 and January 31. As described above, these fish would enter the migratory routes through the Delta interior and be subject to a much lower rate of survival due to multiple factors previously explained. In addition, reduced flows downstream of the open Delta Cross Channel in the mainstem Sacramento River would be expected to reduce survival due to increased transit times and the potential to be entrained into Georgiana Slough.

Water quality concerns typically arise during dry years, when salinity criteria are in danger of being exceeded at key locations in the Delta. During dry years, juvenile SR winter-run Chinook salmon downstream migration is usually delayed until January or February, when winter storms first arrive. The delay in juvenile SR winter-run Chinook salmon entering the Delta region adjacent to the location of the Delta Cross Channel gates may ameliorate the increased potential risk due to the need to open the gates for water quality concerns during the December through January period when drought conditions are observed. After February 1, the gates are closed until May, when all the juvenile SR winter-run Chinook salmon have characteristically exited the Delta. Closure of the Delta Cross Channel gates from February 1 to May 20 protects the last 50 percent of the population that is entering the Delta from entrainment into the interior Delta via the Delta Cross Channel route.

Adult SR winter-run Chinook salmon start entering the Delta in November and continue through June, with a peak presence from February to April. Based on the proposed gate operations for the Delta Cross Channel, adult fish will typically encounter open gates in November when the first fish start to arrive. Upstream passage into the mainstem Sacramento River should not be impeded, even though fish have strayed into the Mokelumne River system. In December and through the end of January, the Delta Cross Channel gates will typically be closed, and adult SR winter-run Chinook salmon are unlikely to be attracted into the Mokelumne River system. This will change, however, if the gates need to be opened for water quality purposes. Under this scenario, when the gates are open, there is a risk of adult SR winter-run Chinook salmon being attracted into the Mokelumne River system by the additional flow of Sacramento River water through the gates. While the expected frequency of opening the Delta Cross Channel gates in December and January to avoid exceeding water quality criteria is not specified in the proposed action, the same action was estimated by Reclamation in the 2019 BA (U.S. Bureau of Reclamation 2023-2024) as occurring in less than 1 in 10 years. When the gates are closed for up to 5 days, these fish risk being caught behind the closed gates, delaying their upstream migration until they drop back downstream and find an alternative route into the Sacramento River watershed. Since adult Chinook salmon have been observed to make several movements upstream and downstream in the Delta waterways before finally moving upstream towards their spawning grounds, the temporary delay should not cause any permanent physiological impairment.

Additional adverse effects from maintenance activities are not expected.

7.5.1.1.5.3.2. Central Valley Spring-Run Chinook Salmon

As indicated in the Presence of the Species Within the Bay-Delta Division section, natural-origin yearling CV spring-run Chinook salmon are expected to enter the Delta in late fall and early winter, and young-of-year juvenile CV spring-run Chinook salmon are expected to be present in the northern Delta region from December through May with a peak presence in April. By the end of January, about 5 percent of a given juvenile CV spring-run Chinook salmon cohort has entered the Delta region near the Delta Cross Channel gates, with the first arrival of juveniles occurring in mid- to late-December. Based on the proposed operations of the Delta Cross Channel gates, up to 5 percent of the juvenile cohort will be exposed to the potential opening of the gates (December through January) in less than 1 in 10 years (based on estimated frequency for the same action in the 2019 BA), which in those years will create an elevated risk of entraining fish into the Delta interior, where survival is reduced compared to remaining in the Sacramento River migratory route. After February 1, when the gates are closed through May 20, approximately 95 percent of the juvenile CV spring-run Chinook salmon cohort will enter the Delta and move through the Sacramento River adjacent to the Delta Cross Channel gates. The effects of operations of the Delta Cross Channel gates for water quality concerns should be similar to that already described for juvenile SR winter-run Chinook salmon and occur only in drier conditions when exceedances of salinity thresholds at key Delta locations are forecasted to occur. Thus, the overall risk of entraining juvenile CV spring-run Chinook salmon into the interior Delta through the Delta Cross Channel gates is low.

Adult CV spring-run Chinook salmon enter the Delta starting in January and continue migrating past the Delta Cross Channel gate location through June, with a peak presence from February to April. Therefore, almost all of the adult migratory period will occur when the gates are closed. There is a small probability that some adults will enter the Delta when the gates are open for water quality purposes in January and be attracted to migrate up through the Mokelumne River system to the open Delta Cross Channel gates, but based on estimated frequency for the same action in the 2019 BA (U.S. Bureau of Reclamation 2019b), these impacts are expected in less than 1 in 10 years. This should not impede migration. As previously explained for adult SR winter-run Chinook salmon, any adults in the Delta Cross Channel, when the gates close following a water quality operation are expected to drop back downstream and re-enter the Sacramento River through a different route. There is no expectation that this minor delay will cause any adverse physiological impacts to adult CV spring-run Chinook salmon.

Additional adverse effects from maintenance activities are not expected.

7.5.1.5.3.3. California Central Valley Steelhead

As indicated in the Presence of the Species Within the Bay-Delta Division section, natural-origin juvenile CCV steelhead are expected to be present in the Sacramento River near the Delta Cross Channel gates year-round, as observations of fish captured in the Sacramento Trawl have occurred in most months. However, few fish are actually observed from May through the fall. Starting in mid-January, observations of juvenile CCV steelhead begin to increase in the Sacramento Trawl at Sherwood Harbor. By the end of January and into early February, approximately 25 percent of the current year's juvenile CCV steelhead passage through this region has occurred. Therefore, this fraction of the annual juvenile CCV steelhead population is at risk of being entrained into the interior Delta through open Delta Cross Channel gates following any water quality associated actions, although the actual fraction present at the time the gates are open is expected to be quite less. While the expected frequency of opening the Delta Cross Channel gates in December and January to avoid exceeding water quality criteria is not specified in the proposed action, the same action was estimated by Reclamation in the 2019 BA (U.S. Bureau of Reclamation 2019b) as occurring in less than 1 in 10 years. Exposure of the juvenile CCV steelhead is expected to result in entrainment into the Delta interior through the open gates and reductions in survival similar to that already described for Chinook salmon is anticipated.

Adult CCV steelhead migrating into the Sacramento River basin will be present in the Sacramento River adjacent to the Delta Cross Channel gate location during their upstream spawning migration, primarily from July through November, peaking in September and October. There is a much smaller peak in February, potentially consisting of kelts returning downstream after spawning from the Sacramento River basin. Therefore, most of the adult CCV steelhead population migrating upstream will encounter the Delta Cross Channel gates in an open position from July through November. Adult CCV steelhead from the Sacramento River basin populations will be able to pass upstream either from the mainstem Sacramento River migratory route or from the Mokelumne River system through the open Delta Cross Channel gates if they had strayed into the San Joaquin River system. Kelts returning downstream in late winter/early spring will pass by the Delta Cross Channel gates while they are closed and remain in the main

stem of the Sacramento River. Remaining in the mainstem channel will allow fish to have shorter transit times to the lower tidal Delta and follow a more direct route to the estuary.

Additional adverse effects from maintenance activities are not expected.

7.5.1.5.3.4. Southern Distinct Population Segment of Green Sturgeon

Little information exists regarding the behavior of juvenile sDPS green sturgeon and their risk of entrainment through the Delta Cross Channel gates when open. Acoustically tagged juvenile sDPS green sturgeon have been detected entering the Delta Cross Channel when the gates are open during their downstream movements. Furthermore, the changes in survival for juvenile sDPS green sturgeon using different routes through the Delta are unknown. The fact that juvenile sDPS green sturgeon may spend an extended period of time rearing in the waterways of the Delta (from a few months to 2 to 3 years) complicates assigning a survival rate to any given potential migratory route.

Adult sDPS green sturgeon may be impacted by the potential for delay behind the closed gates during their upstream migration. Acoustic tagging efforts to date indicate that tagged fish typically move upriver through the mainstem of the Sacramento River in the Delta and not within the interior Delta waters adjacent to the downstream channel of the Delta Cross Channel. However, observations of adult sDPS green sturgeon in areas such as the Yolo Bypass following inundation indicate that adults may follow alternate routes if flows and olfactory cues originating from the Upper Sacramento River are present. If the Delta Cross Channel gates are open, some adult migrants may inadvertently enter the downstream sections of the Mokelumne River system and continue upstream in this system to the location of the Delta Cross Channel gates, following the scent of the Sacramento River inflow. If the gates are then subsequently closed before they reach the location of the Delta Cross Channel gates, they would be subject to migrational delays during their spawning runs below the closed Delta Cross Channel gates. In this situation, adult sDPS green sturgeon could drop back downstream and find an alternative route back to the main stem of the Sacramento River to continue their spawning migration upriver.

Additional adverse effects from maintenance activities are not expected.

Table 120 summarizes the individual species analysis of exposure, and response associated with the consequences of the proposed action element: operation of the Delta Cross Channel gates, including closure, maintenance, and repair.

Table 120. Information used to identify the effects of the proposed action, Delta Cross Channel Gate closures (and maintenance and repair) on species.

Proposed Action element	Species	Stressors	Life Stage (Location)	Life Stage Timing (Work Window Intersection)	Individual Response and Rationale of Effect	Severity of Stressor	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence
Delta Cross Channel	Sacramento River winter-run Chinook salmon	Straying or delayed migration	Adult (N. Delta)	November - June (varies November - January)	Altered or delayed migration; increase to straying; reduced spawning success	Minor to Subletha l	Medium	High, gates open annually	Medium	Low - Number of studies/publications regarding adult salmonid homing/straying but few related to Delta Cross Channel gate operations
Delta Cross Channel	Sacramento River winter-run Chinook salmon	Flow (routing) and predation	Juvenile (N. Delta)	October - April (varies October - January)	Altered or delayed migration; increase risk to predation; reduced survival	Subletha l to Lethal	Medium, (16% to 19%)	High, gates open annually,	High	High - Number of studies/publications regarding the relative survival in various North Delta and Central Delta migratory routes; conclusions supported by modeling results
Delta Cross Channel	Central Valley spring-run Chinook salmon	Straying or delayed migration	Adult (N. Delta)	January - May	Altered or delayed migration; increase to straying; reduced spawning success	Minor to Subletha l	Small (<2%)	Low, gates open Dec. - Jan., 1 in 10 years	Low	Low - Number of studies/publications regarding adult salmonid homing/straying but few related to Delta Cross Channel gate operations

Proposed Action element	Species	Stressors	Life Stage (Location)	Life Stage Timing (Work Window Intersection)	Individual Response and Rationale of Effect	Severity of Stressor	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence
Delta Cross Channel	Central Valley spring-run Chinook salmon	Flow (routing) and predation	Juvenile (N. Delta)	Young-of-year: December - June (December - January) Yearling: November - February (November - January)	Altered or delayed migration; increase risk to predation; reduced survival	Subletha l to Lethal	Young-of-year: Small (<2%) Yearling: Medium	Low, gates open Dec. - Jan., 1 in 10 years, High, gates open annually	Young-of-year: Low Yearling: Medium	High - Number of studies/publications regarding the relative survival in various North Delta and Central Delta migratory routes; conclusions supported by modeling results
Delta Cross Channel	California Central Valley steelhead	Straying or delayed migration	Adult (N. Delta)	August - May (August - January)	Altered or delayed migration; increase to straying; reduced spawning success	Minor to Subletha l	Large (>93%)	High, gates open annually	Medium	Low - Number of studies/publications regarding adult salmonid homing/straying but few related to Delta Cross Channel gate operations
Delta Cross Channel	California Central Valley steelhead	Flow (routing) and predation	Juvenile (N. Delta)	January - June (January)	Altered or delayed migration; increase risk to predation; reduced survival	Subletha l to Lethal	Medium (5% to 6%)	High, gates open annually	Medium to High	High - Number of studies/publications regarding the relative survival in various North Delta and Central Delta migratory routes; conclusions supported by modeling results

Proposed Action element	Species	Stressors	Life Stage (Location)	Life Stage Timing (Work Window Intersection)	Individual Response and Rationale of Effect	Severity of Stressor	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence
Delta Cross Channel	Southern Distinct Population Segment of green sturgeon	Delayed migration	Adult (N. Delta)	June - May (June - January)	Altered migration; reduced spawning success	Minor to Subletha l	Medium	High, gates open annually	Medium	Low - Limited understanding of hydrological influence on adult sturgeon migration in the Delta
Delta Cross Channel	Southern Distinct Population Segment of green sturgeon	Flow (routing) and predation	Juvenile/su b-adult (N. Delta)	June - May (June - January)	Altered migration; reduced growth	Minor to Subletha l	Medium	High, gates open annually	Medium	Low - Limited understanding of hydrological influence on juvenile/subadult sturgeon migration in the Delta

7.5.1.6. Old and Middle River Flow Management

Net OMR flow provides a surrogate indicator for how export pumping at the Banks and Jones pumping plants influence hydrodynamics in the South Delta. Reclamation proposes to manage OMR flows (calculated based on the equation in Hutton [2008]), in combination with other environmental variables, to address the entrainment of fish in the South Delta and at CVP and SWP fish salvage facilities. The key differences between the proposed action and the current operations, represented by the NAA scenario, include the following:

- Removing the salmonid trigger for onset of OMR flow management when 5 percent of a population is estimated to be present in the Delta and the offramp when 95 percent of a salmonid population has migrated past Chipps Island or when daily mean water temperature at Mossdale has exceeded 71.6°F for 7 days in June. OMR management for CCV steelhead offramps on June 15. The proposed action now concludes OMR management on June 30 or when both Mossdale and Prisoner's Point exceed 71.96°F for 7 days in June. This is not expected to change the timing of the OMR flow management onramp and offramp, since species distribution timing is typically associated with water temperatures in the Delta. The revised temperature offramps should result in similar offramp timing as under the current operations.
- The loss thresholds for SR winter-run Chinook salmon are different in that:
    - They are based on the historical loss of genetic SR winter-run Chinook salmon, rather than the historical loss of LAD SR winter-run Chinook salmon.
    - There are weekly loss thresholds tracked within a water year.
- The loss thresholds for CCV steelhead are also different in two key ways:
    - Rather than the two periods/seasons (e.g., separate for Sacramento River and San Joaquin River) for tracking cumulative annual loss, there is a single annual loss threshold for the entire calendar year (July 1 through June 30).
    - In addition to the annual loss threshold, there are weekly loss thresholds tracked within a water year. If the 7-day rolling loss sum (calculated daily) exceeds 120 fish, Reclamation will reduce exports so OMR is no more negative than -3,500 cfs.

Unless specified otherwise below, Reclamation and DWR will restrict exports in response to meeting Chinook salmon thresholds based on the initial LAD identification of juvenile Chinook salmon. If genetic analysis indicates that any given Chinook salmon is not part of the run targeted by a particular threshold, these fish will not count towards the loss threshold exceedance, and continued export adjustments pursuant to the OMR limit may not be required. Given that SHERLOCK is a new methodology currently undergoing peer review and field testing, both methodologies will be used to determine the final identification. In the event that SHERLOCK and GT-seq provide different run assignments, the results from the GT-seq method will be used to determine the final run assignment for the purposes of implementing this early season migration action. If a fish is not genetically identifiable or if genetic identification is pending, then the Delta model LAD criteria shall be used to classify the race of the juvenile Chinook salmon in salvage.

7.5.1.6.1. Sacramento River Winter-Run Chinook Salmon Early Season Migration

To manage entrainment and salvage of early-migrating natural older SR winter-run Chinook salmon, DWR and Reclamation will adjust exports to achieve a 7-day of the average OMR value no more negative than -5,000 cfs for 7 consecutive days, to be assessed on the seventh day of the averaging period after initiating operational changes in response to the OMR trigger, when the genetically verified 7-day rolling sum of SR winter-run Chinook salmon loss, calculated daily, exceeds the following annually calculated thresholds:

- November 1–November 30: 0.0044 percent of the Red Bluff juvenile SR winter-run Chinook salmon Brood Year Total at the end of the second biweekly period in October.
- December 1–December 31: 0.0084 percent of the Red Bluff juvenile SR winter-run Chinook salmon Brood Year Total at the end of the second biweekly period in November.

If the 7-day rolling sum of SR winter-run and CV spring-run Chinook salmon loss, calculated daily, is exceeded during a period of reduced exports, DWR and Reclamation will continue to reduce exports to achieve a 7-day average OMR value no more negative than -5,000 cfs until 7 days after the most recent exceedance.

7.5.1.6.2. Central Valley Spring-Run Chinook Salmon

Reclamation and DWR, through SaMT, will use real-time monitoring data, coupled with new science gained through ongoing efforts, to develop a CV spring-run Chinook salmon JPE and life cycle model to inform weekly risk assessments (October through June) for natural-origin juvenile CV spring-run Chinook salmon. If the risk assessment identifies a more positive OMR flow is needed to minimize the take of natural-origin juvenile CV spring-run Chinook salmon, WOMT may consider a more positive OMR flow requirement.

7.5.1.6.3. Start of Old and Middle River Management

The OMR management season starts:

- After December 1, if an Adult Longfin Smelt Entrainment Protection Action is triggered, or
- Upon occurrence of First Flush Action (i.e., reduce exports to maintain a 14-day average OMR index no more negative than -2,000 cfs when the 3-day running average of daily flows at Freeport is greater than or equal to 25,000 cfs, and the 3-day running average of daily turbidity at Freeport is greater than or equal to 50 Formazin Nephelometric Units [FNU]), or
- After December 20, if the turbidity threshold in the Adult Delta Smelt Entrainment Protection Action is reached.

If neither the Adult Longfin Smelt Entrainment Protection Action or First Flush Action occurs or the Adult Delta Smelt Entrainment Protection Action is reached, the OMR management season starts on January 1. Once initiated, the OMR index on a 14-day running average will be no more negative than -5,000 cfs until the end of the OMR management season. Reclamation and DWR will make reductions to exports within 3 days of a trigger.

Real-Time Adjustments

Reclamation and DWR shall manage to a more positive OMR than -5,000 cfs on a 14-day average based on the following:

- Adult Delta Smelt Entrainment Protection Action (Turbidity Bridge): If after a First Flush Action or after December 20, whichever occurs first, daily average turbidity remains or increases to 12 FNU or higher at Holland Cut, Old River at Bacon Island, and Old River at Frank's Tract near Terminous turbidity sensors in the OMR corridor, Reclamation and DWR will manage exports to achieve a 5-day average OMR flow no more negative than -3,500 cfs until the daily average turbidity in at least one of the three turbidity sensors is less than 12 FNU for 2 consecutive days. This action is intended to provide a sufficient time to allow turbidity values to lessen and reduce the movement of Delta smelt to areas of high entrainment risk.

  If the three turbidity sensors remain over 12 FNU at the end of a High Flow Off-Ramp or any time after 5 consecutive days, then Reclamation and DWR, through WOMT, may prepare an assessment to determine if another Adult Delta Smelt Entrainment Protection Action is warranted based on continued entrainment risk. The Adult Delta Smelt Entrainment Protection Action ends when the 3-day continuous average water temperatures at Jersey Point or Rio Vista reach 53.6°F (12°C).

  When San Joaquin River flows at Vernalis are greater than 10,000 cfs, the Adult Delta Smelt Entrainment Protection Action (Turbidity Bridge) is offramped. While offramped, the OMR Index will be managed to be no more negative than -5,000 cfs on a 14-day average. The Adult Delta Smelt Entrainment Protection Action (Turbidity Bridge) would be immediately reinstated when San Joaquin River flows at Vernalis drop below 8,000 cfs.

- Adult Longfin Smelt Entrainment Protection Action: An action response is triggered if cumulative water year salvage of longfin smelt with fork length greater than or equal to 60 millimeters at the CVP and SWP facilities exceeds the salvage threshold, where the salvage threshold = (Age 1+ longfin smelt index/20) + 1. If triggered:

  - From December 1 to the start of the OMR management season, Reclamation and DWR shall operate to an OMR flow no more negative than -5,000 cfs on a 7-day average for 7 consecutive days, to be assessed on the seventh day of the averaging period after initiating operational changes in response to the OMR trigger, and then, if appropriate, initiate the start of OMR management season.

  - From the start of the OMR management season to the end of February, Reclamation and DWR shall operate to an OMR flow no more negative than -3,500 cfs on a 7-day average for 7 consecutive days, to be assessed on the seventh day of the averaging period after initiating operational changes in response to the OMR trigger.

  - If salvage of longfin smelt ≥ 60 mm continues following the initial 7-day action response, then Reclamation and DWR, through WOMT, may prepare an assessment to determine if additional longfin smelt entrainment protection action

is warranted based on continued entrainment risk. See Section 3.7.4.4.1 of the BA for more details (U.S. Bureau of Reclamation 2023-2024).

7.5.1.6.4. Larval and Juvenile Delta Smelt Protection Action

Larval and juvenile Delta smelt protections start upon the end of the Adult Delta Smelt Entrainment Protection Action. Reclamation and DWR will operate South Delta exports to a 7-day average OMR index no more negative than -5,000 cfs when the average Secchi disk depth in the most recent survey is greater than 1 meter. If the average Secchi disk depth is less than 1 meter, Reclamation and DWR will operate to an OMR index no more negative than -3,500 cfs until the average Secchi depth has increased to more than 1 meter.

7.5.1.6.5. Larval and Juvenile Longfin Smelt Protection Action

From January 1 through the end of the OMR management season, Reclamation and DWR will restrict the 7-day average OMR flow to no more negative than -3,500 cfs for 7 days, to be assessed on the seventh day of the averaging period after initiating operational changes in response to the OMR trigger if:

- The 7-day average QWEST is less than +1,500 cfs (as calculated using the Dayflow QWEST equation, which estimates the net westward flow of the San Joaquin River at Jersey Point), and
- Larval and juvenile longfin smelt catch in the most recent Smelt Larva Survey or 20-millimeters survey at stations 809 and 812 exceeds the catch threshold set by the San Francisco Bay Study longfin smelt index.

Upon initiation of the action DWR and Reclamation, through WOMT, may prepare an assessment to determine if the 7-day action can be adjusted or offramped based on larval and juvenile longfin smelt entrainment risk.

If the water year cumulative juvenile longfin smelt salvage at the CVP and SWP facilities exceeds 50 percent of the average annual salvage observed from 2009 through the water year preceding the current water year, then Reclamation and DWR shall adjust to a seven-day average of the OMR of -3,500 cfs for 14 days, to be assessed on the seventh day of the averaging period after initiating operational changes in response to the OMR trigger. If the water year cumulative juvenile longfin smelt salvage at the CVP and SWP facilities during this period exceeds 75 percent of the average annual salvage observed from 2009 through the water year preceding the current water year, then Reclamation and DWR shall adjust to a seven-day average of the OMR of -2,500 cfs for 14 days, to be assessed on the seventh day of the averaging period after initiating operational changes in response to the OMR trigger. If salvage of larval and juvenile longfin smelt continues following the 14-day period where OMR is no more negative than -2,500 cfs, then WOMT may request Reclamation and DWR, through the SMT, a risk assessment on appropriate OMR flows through the remainder of the OMR Management.

7.5.1.6.6. Sacramento River Winter-Run Chinook Salmon Annual Loss Threshold

Reclamation and DWR will manage OMR to avoid exceeding the following annual loss thresholds:

- Natural SR winter-run Chinook salmon (loss = 0.5% of JPE)

- Hatchery SR winter-run Chinook salmon (loss = 0.12% of JPE)

JPEs and annual loss thresholds will be calculated for natural SR winter-run Chinook salmon and for each of the hatchery SR winter-run Chinook salmon populations from LSNFH and Battle Creek. The JPE for natural and hatchery SR winter-run Chinook salmon will be calculated at least annually by the JPE SubTeam, as described in Appendix- Winter-Run Juvenile Production Estimate, and transmitted to WOMT and SHOT. Hatchery releases of SR winter-run Chinook salmon will be tracked individually, and cumulative loss will be summed across release groups with the same JPE and annual loss threshold

Annual loss of natural and hatchery SR winter-run Chinook salmon at the CVP and SWP salvage facilities will be counted for each brood year, starting July 1 of the calendar year through June 30 of the following calendar year. If cumulative loss of natural or hatchery SR winter-run Chinook salmon in a brood year exceeds 50 percent of the annual loss thresholds, then DWR and Reclamation will restrict South Delta exports to maintain a 7-day average OMR value no more negative than -3,500 cfs for 7 consecutive days, to be assessed on the seventh day of the averaging period after initiating operational changes in response to the OMR trigger.

If the cumulative loss of natural or hatchery SR winter-run Chinook salmon in a brood year exceeds 75 percent of the annual loss thresholds, and the Winter-Run Chinook Salmon Machine Learning Model and associated OMR Conversion Tool predict that a change of OMR to -2,500 cfs will shift the model output to a classification of absence with a minimum probability of absence prediction of 0.559 for one of 30 sub-models for any of the 7 most recent prediction days, then DWR and Reclamation will restrict South Delta exports to maintain a 7-day average OMR value no more negative than the -2,500 cfs for 7 consecutive days, to be assessed on the seventh day of the averaging period after initiating operational changes in response to the OMR trigger.

If the cumulative loss of either natural or hatchery-origin SR winter-run Chinook salmon in a brood year exceeds 100 percent of the annual loss thresholds, then DWR and Reclamation will immediately convene the SaMT to review recent fish distribution information and operations and provide advice regarding future planned SWP and CVP operations to minimize subsequent loss during that year. The SaMT will report the results of this review and advice to the WOMT. Operational decisions will be made following the governance process described in Section 3.3.18 of the BA. If either annual loss threshold is exceeded, DWR and Reclamation will also convene an independent peer review panel to review SWP and CVP operations and the annual loss thresholds prior to November 1. The purpose of the independent peer review is to review the actions and decisions contributing to the loss trajectory that led to an exceedance of an annual loss threshold, and make recommendations on modifications to SWP and CVP operations, or additional actions to be conducted to stay within the annual loss thresholds in subsequent years.

7.5.1.6.7. Sacramento River Winter-Run Chinook Salmon Weekly Distributed Loss Threshold

Reclamation and DWR will manage the OMR index based on a weekly distributed loss threshold. The weekly loss threshold is the weekly percentage of natural SR winter-run Chinook salmon present in the Delta, scaled to 100 percent (

Table 121, Column E) and 50 percent of the total natural SR winter-run Chinook salmon annual loss threshold. If the weekly distributed loss threshold is exceeded on any single day by the 7-

day rolling sum of SR winter-run Chinook salmon loss, then DWR and Reclamation will reduce exports to achieve a 7-day average OMR no more negative than -3,500 cfs for 7 consecutive days.

The averaging period for OMR will begin within 3 days of a criterion being exceeded. Each week, Reclamation and DWR, through SaMT, will compare weekly Delta entry and exit information to determine if the present data is tracking with the historical distribution data. Reclamation and DWR, through SaMT, may adjust subsequent weekly loss thresholds based on year-specific conditions. At the conclusion of the OMR management season, Reclamation and DWR will review and may adjust the historical distribution table, through SaMT, for the following year.

Table 121. Historical (water years 2017–2021) presence of Sacramento River winter-run Chinook salmon entering the Delta (Column B), exiting the Delta (Column C), in the Delta (Column D = Column B - Column C), and in the Delta scaled to 100 percent (Column E).

(A) Week (starting January 1)	(B) Historical Cumulative entering the Delta (Sherwood Harbor)	(C) Historical Cumulative exiting the Delta (Chipps Island)	(D) Historical Present in Delta	(E) Historical Present in Delta (Scaled to 100%)
1/1–1/7	2.47%	1.65%	0.82%	0.32%
1/8–1/14	2.47%	1.65%	0.82%	0.32%
1/15–1/21	4.94%	1.65%	3.29%	1.30%
1/22–1/28	4.94%	1.65%	3.29%	1.30%
1/29–2/4	19.75%	2.20%	17.55%	6.91%
2/5–2/11	38.27%	4.95%	33.32%	13.13%
2/12–2/18	43.21%	5.49%	37.72%	14.86%
2/19–2/25	46.91%	9.89%	37.02%	14.59%
2/26–3/4*	50.62%	18.13%	32.49%	12.80%
3/5–3/11	55.56%	30.77%	24.79%	9.77%
3/12–3/18	77.78%	38.46%	39.32%	15.49%
3/19–3/25	85.19%	64.84%	20.35%	8.02%
3/26–4/1	93.83%	90.11%	3.72%	1.47%
4/2–4/8	98.77%	99.45%	0%	0%
4/9–4/15	100.00%	100.00%	0.00%	0.00%

(A) Week (starting January 1)	(B) Historical Cumulative entering the Delta (Sherwood Harbor)	(C) Historical Cumulative exiting the Delta (Chipps Island)	(D) Historical Present in Delta	(E) Historical Present in Delta (Scaled to 100%)
4/16-End of Winter-run OMR Season	100.00%	100.00%	0.00%	0.00%

OMR = Old and Middle rivers
* The week of 2/26–3/4 includes 8 days during leap years

Source: Table 3-11 in (U.S. Bureau of Reclamation 2023-2024)

7.5.1.6.8. Steelhead Annual Threshold

Reclamation and DWR will manage OMR to avoid exceeding the following annual loss threshold at CVP and SWP salvage facilities through the weekly distributed loss threshold of 3,000 unclipped juvenile CCV steelhead. Annual loss at the CVP and SWP salvage facilities will be counted cumulatively for each brood year, starting July 1 through June 30 of the following calendar year.

7.5.1.6.9. Steelhead Weekly Distributed Loss Threshold

The CCV steelhead weekly loss threshold is the annual loss threshold distributed over the period of observed CCV steelhead salvage between January 1 and June 30 using the 7-day weekly periods identified in the weekly distributed loss table for SR winter-run Chinook salmon (

Table 121), extended through June 30. DWR and Reclamation will reduce exports to achieve a 7-day average OMR value no more negative than -3,500 cfs for 7 consecutive days when the 7-day rolling sum of CCV steelhead salvage, calculated daily, exceeds the weekly loss threshold of 120 fish.

7.5.1.6.10. Central Valley Spring-Run Chinook Salmon and Surrogate Threshold

Reclamation and DWR will restrict exports based on the presence of hatchery-produced CV spring-run, yearling late-fall-run, and young-of-year fall-run Chinook salmon surrogate groups at the CVP and SWP salvage facilities. Reclamation and DWR, in coordination with CDFW, NMFS, and USFWS through the SaMT, will select CV spring-run Chinook salmon yearling and young-of-year surrogate groups. Yearling CV spring-run Chinook salmon surrogates will be selected from late-fall Chinook salmon in-river release groups from the Coleman National Fish Hatchery. Central Valley spring-run Chinook salmon young-of-year and associated surrogate groups will be selected from fall-run and CV spring-run Chinook salmon in-river release groups from the FRFH and Coleman National Fish Hatchery.

From November 1 through the end of the OMR flow management period of each water year, if a cumulative loss threshold is exceeded, Reclamation and DWR will reduce South Delta exports to achieve a 7-day average OMR index of no more negative than -5,000 cfs in November and December and no more negative than -3,500 cfs beginning January 1, or whenever the OMR management begins, through the end of the OMR flow management season, or June 30, whichever occurs first. The cumulative loss threshold for CWT CV spring-run Chinook salmon

surrogate groups at the CVP and SWP salvage facilities is 0.25 percent for each release group. See Section 3.7.4.5.7 of the BA for more details (U.S. Bureau of Reclamation 2023-2024).

7.5.1.6.11. Storm-Flex

Reclamation and DWR, through WOMT, may prepare an assessment to evaluate operating to an OMR index no more negative than -6,250 cfs between the start of OMR management season and the larval and juvenile Delta Smelt Protection Action onramp, or the last day of February, whichever occurs first, to capture peak flows during storm-related events when:

- The Delta is in excess conditions as defined in the 1986 Coordinated Operations Agreement, as amended in 2018; and
- QWEST is greater than +1,500 cfs; and
- X2 is less than 81 kilometers; and
- The daily average turbidity at the Holland Cut, Old River at Bacon Island, and Old River at Frank's Tract sensors is less than 12 FNU at each station; and
- A measurable precipitation event has occurred in the Central Valley; and
- Reclamation and DWR determine that the net Delta outflow index indicates a higher level of outflow available for diversion due to peak storm flows; and
- None of the additional real-time OMR protections are controlling project operations; and
- Cumulative loss of the CVP and SWP export facilities of yearling Coleman National Fish Hatchery late-fall-run Chinook salmon (yearling CV spring-run Chinook salmon surrogate) is less than 0.5 percent within any of the release groups.

If the above criteria are met, WOMT will determine whether real-time distribution of listed-species estimates from the Smelt Monitoring Team and SaMT should be used, as well as PTM and prediction tool output to assess entrainment risk differences using OMR inputs of -5,000 cfs and -6,250 cfs. If the assessment indicates that no additional real-time OMR thresholds for the upcoming week are likely to be triggered, Reclamation and DWR will request from WOMT approval to operate to OMR no more negative than -6,250 cfs and will update the assessment no less than weekly.

If conditions indicate an additional real-time OMR protection is likely to be triggered, Reclamation and DWR will adjust South Delta exports to achieve a 14-day average OMR index no more negative than -5,000 cfs, unless a further reduction in exports is required. If an entrainment protection condition is triggered, Reclamation and DWR will cease storm-flex and implement the entrainment protection condition. Storm-flex decisions will be re-evaluated weekly by WOMT.

7.5.1.6.12. End of Old and Middle River Management Season

The OMR Management season for Delta smelt and longfin smelt will conclude when the 3 consecutive days of water temperature at CCF is 77.0°F (25°C) or higher, or on June 30, whichever occurs first.

Reclamation and DWR will conclude the management of OMR for salmonids on June 30 or when the following conditions have occurred, whichever occurs first:

- Daily mean water temperature at Mossdale has exceeded 71.96°F (22.2°C) for 7 non-consecutive days (does not have to be consecutive) in June; and

- Daily mean water temperature at Prisoner's Point has exceeded 71.96°F (22.2°C) for 7 non-consecutive days (does not have to be consecutive) in June.

7.5.1.6.13. End of Year Evaluation

Each year, Reclamation and DWR, in coordination with SaMT, will conduct an annual assessment of OMR protection measures for listed salmonids, which will include an evaluation of salvage, management actions, and physical conditions, in a seasonal report. This seasonal report will fulfill commitments under the ROD and will inform any 4-Year Review Panels adopted under the ROD.

7.5.1.6.14. Assess Exposure to Species from Old and Middle River Flow Management

The temporal and spatial occurrence of SR winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon in the Delta is intrinsic to their natural history and summarized in the Status of the Species. A more detailed description of the presence of these species in the Delta is given in Table 111. The OMR flow management component in the proposed action (and any associated changes in exports) is not expected to affect the overall seasonal presence of listed salmonids and sDPS green sturgeon in the Delta. Annual loss is expected to continue at a similar level under the 2024 proposed action. Salvage timing of each species over the past 25 years is shown in Figure 144, Figure 145, Figure 146, and Figure 147.

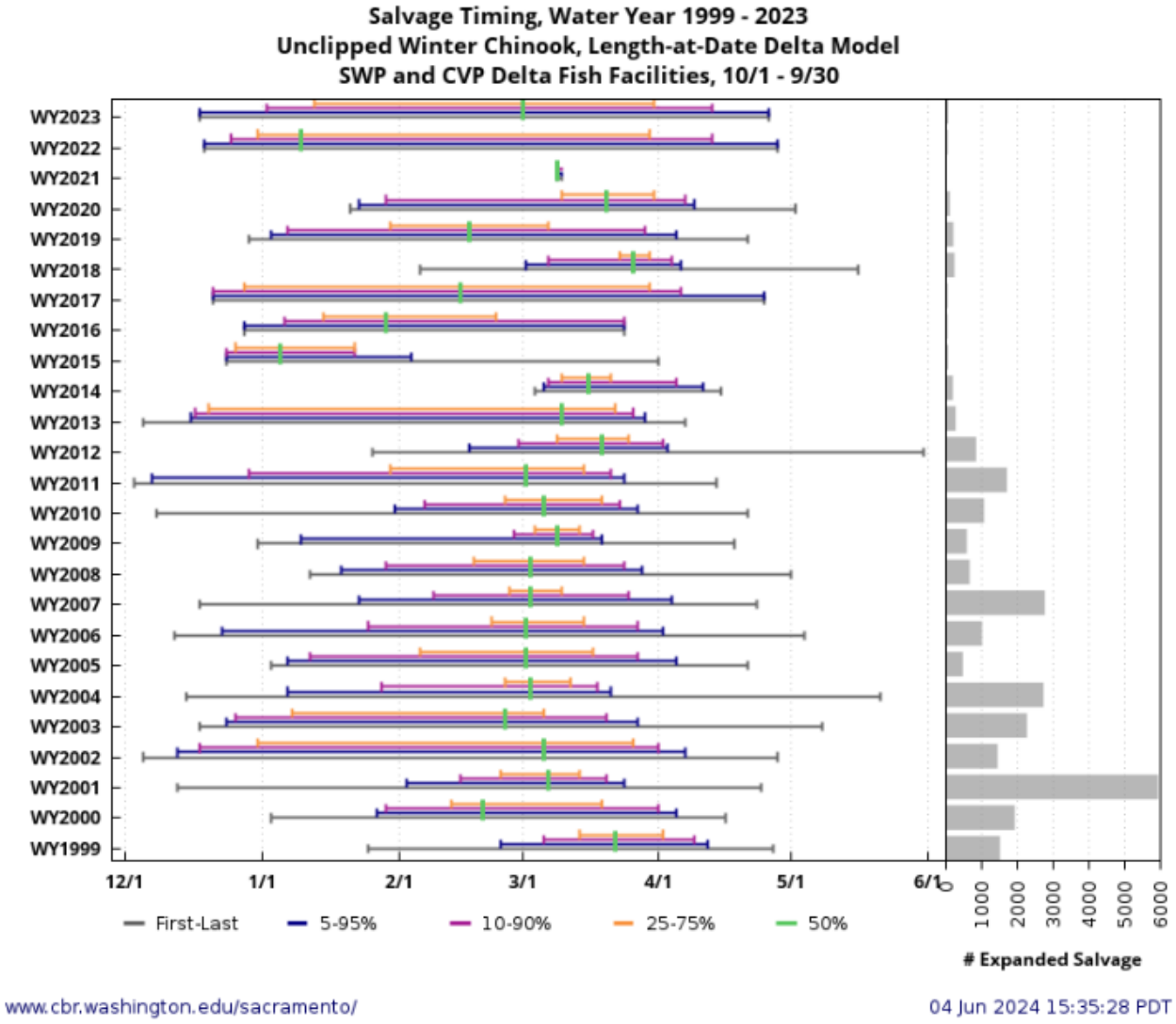


Figure 144. Salvage timing of Sacramento River winter-run Chinook salmon (length-at-date) for water years 1999–2023. Annual salvage is shown in the right column.

Source: SacPAS (University of Washington Columbia Basin Research 2024a)

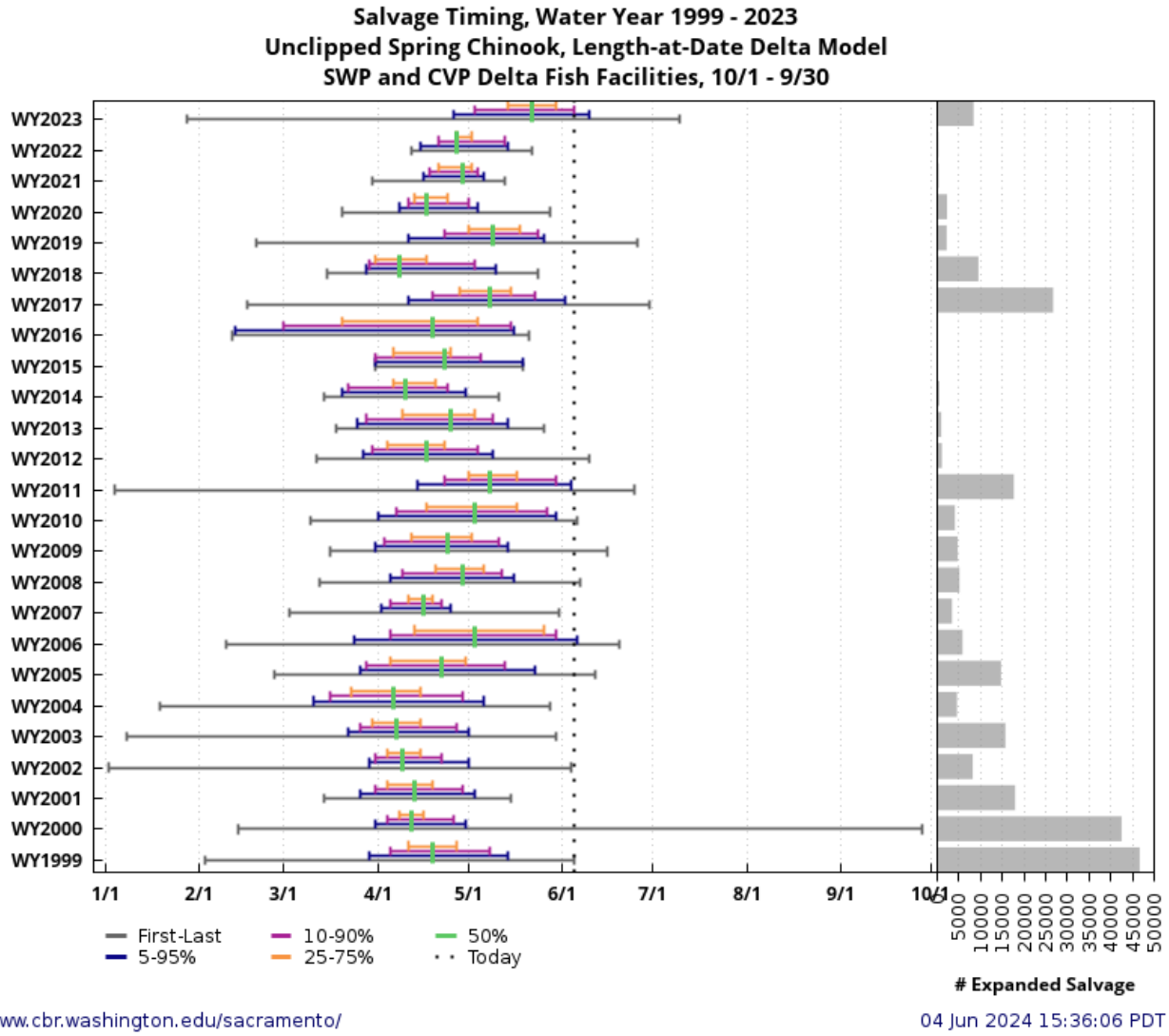


Figure 145. Salvage timing of Central Valley spring-run Chinook salmon (length-at-date) for water years 1999–2023. Annual salvage is shown in the right column.

Source: SacPAS (University of Washington Columbia Basin Research 2024a)

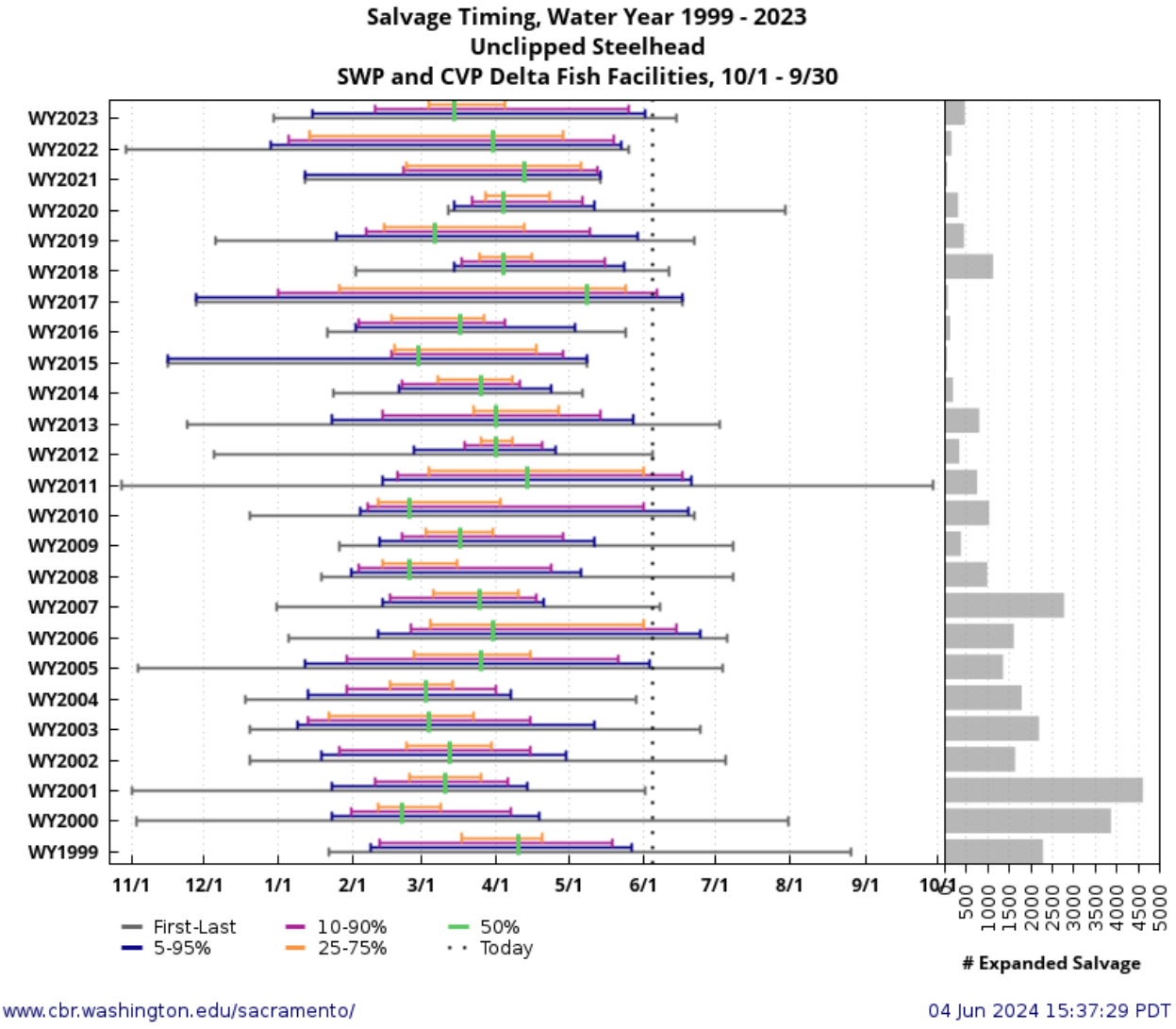


Figure 146. Salvage timing of California Central Valley steelhead for water years 1999–2023. Annual salvage is shown in the right column.

Source: SacPAS (University of Washington Columbia Basin Research 2024a)

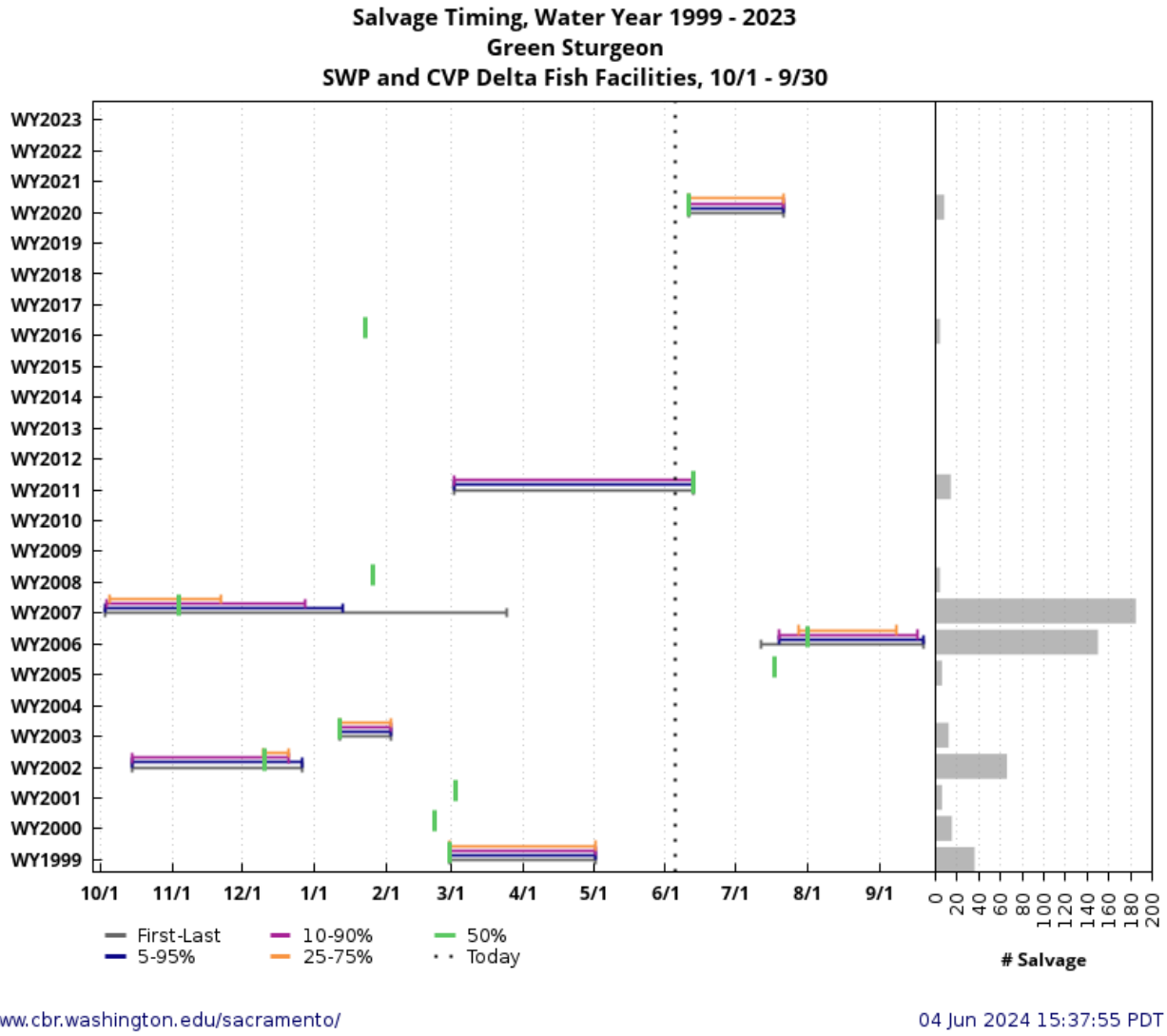


Figure 147. Salvage timing of green sturgeon for water years 1999–2023. Annual salvage is shown in the right column.

Source: SacPAS (University of Washington Columbia Basin Research 2024a)

There is interannual variability in loss rates observed for natural origin and hatchery salmonids, and sDPS green sturgeon are rarely observed in salvage. Some of this variability is likely due to interannual variability in population size. Other sources of variability that may influence loss rates include juvenile survival to the Delta, the fraction of juveniles that route into the South Delta where fish are vulnerable to entrainment, hydrologic conditions, and operations. The mix of single-year and long-term cumulative loss thresholds is designed to accommodate this interannual variability while controlling for long-term loss.

7.5.1.6.15. Assess Response to Species from Old and Middle River Flow Management

NMFS' approach to linking hydrodynamics with species responses is described earlier in the Delta effects section. To understand the species responses, NMFS assesses the likely

hydrodynamic conditions under the proposed action, based on information provided in the modeling results.

Instead of using loss thresholds based on LAD SR winter-run Chinook salmon, as in the 2019 proposed action, Reclamation is proposing to use loss thresholds based on genetically confirmed SR winter-run Chinook salmon. Modeling results provided by Reclamation rely on historical data and may not be accurately predicting OMR flows under the proposed action, since thresholds may not be triggered as frequently using genetic SR winter-run Chinook salmon, since observations are becoming rarer. Due to the low number of individuals expected to be present in the Delta, they are less likely to be observed in salvage, and exceeding thresholds are less likely to occur. If increasing rarity results in real-time OMR protections being triggered less often than modeled, it could result in an increase in listed-fish species entrainment at fish salvage facilities and an overall decrease in survival to individual SR winter-run Chinook salmon that may be present in the South Delta.

In addition to the assumed OMR frequencies assumed for the CalSim modeling, which are described in detail in Attachment 1-2, Modeled Representation of Old and Middle River Actions to Appendix F: Modeling, NMFS considered a CDFW analysis (California Department of Fish and Wildlife 2024a) that evaluated the extent of OMR action responses under current operations (which includes implementation by DWR of daily SR winter-run Chinook salmon loss thresholds per Condition of Approval 8.6.3 in the 2020 SWP ITP) and the proposed SR winter-run Chinook salmon weekly distributed loss thresholds. Based on historical loss observed in water years 2010-2022, CDFW evaluated the expected number of exceedances, and number of action response days, by water year (Table 122) and by month (Table 123).

Table 122. Number of threshold exceedances for the updated 2020 State Water Project Incidental Take Permit (SWP ITP) daily loss thresholds (column B), weekly distributed loss thresholds (column D), number of Old and Middle River action response days for the updated 2020 SWP ITP daily loss thresholds (column C), and weekly distributed loss thresholds (column E) for water years 2010–2022.

(A) Water Year	(B) Daily Loss Threshold Exceedances	(C) Daily Loss Threshold Action Response Days	(D) Weekly Distributed Loss Threshold Exceedances	(E) Weekly Distributed Loss Threshold Action Response Days
2010	1	5	18	41
2011	49	86	57	75
2012	31	73	43	51
2013	1	5	9	15
2014	0	0	0	0
2015	4	20	0	0
2016	5	19	1	7
2017	9	40	0	0

(A) Water Year	(B) Daily Loss Threshold Exceedances	(C) Daily Loss Threshold Action Response Days	(D) Weekly Distributed Loss Threshold Exceedances	(E) Weekly Distributed Loss Threshold Action Response Days
2018	14	29	18	26
2019	2	10	23	35
2020	0	0	15	27
2021	0	0	0	0
2022	3	15	0	0
Total	**119**	**302**	**184**	**277**

Source: (Modified from Table 4 in (California Department of Fish and Wildlife 2024a)

Table 123. Total number of threshold exceedances per month for the updated 2020 State Water Project Incidental Take Permit (SWP ITP) daily loss thresholds (column B), weekly distributed loss thresholds (column D), OMR action response days per month for the updated 2020 SWP ITP daily loss thresholds (column C), and weekly distributed loss thresholds (column E) for water years 2010–2022 combined.

(A) Month	(B) Daily Loss Threshold Exceedances	(C) Daily Loss Threshold Action Response Days	(D) Weekly Distributed Loss Threshold Exceedances	(E) Weekly Distributed Loss Threshold Action Response Days
January	29	76	16	31
February	23	64	14	23
March	50	88	89	99
April	14	55	65	114
May	3	17	0	10
June	0	2	0	0
Total	**119**	**302**	**184**	**277**

Source: Modified from Table 5 in (California Department of Fish and Wildlife 2024a)

The expected number of action response days under the weekly loss threshold approach in the proposed action (277 days) is similar to what was observed under the daily loss threshold approach implemented by DWR at the SWP in current operations (302 days). There are some differences across years between the different approaches (Table 122). For example, using the 2017 loss data, the daily loss threshold approach results in 40 days of action response, while the proposed weekly loss threshold approach results in zero days of action response. In contrast,

using the 2020 loss data, the daily loss threshold approach results in zero days of action response, while the proposed weekly loss threshold approach results in 27 days of action response. CDFW's analysis also showed some differences in the distribution of exceedances across months (Table 123). The most notable differences are that, relative to the daily loss thresholds implemented by DWR at the SWP in current operations, the proposed weekly loss thresholds resulted in fewer action response days in January and February and more action response days in April.

Reclamation's modeling results provide simulations for OMR flows under the proposed action in Appendix F: Modeling (U.S. Bureau of Reclamation 2023-2024), based on historical data, to provide expected conditions under the proposed action. Table 124 shows monthly CalSim 3 outputs under Alt2v2 (also referred to as Alt2woTUCPDeltaVA), which is phase 1 of the proposed action with Delta VAs, which will occur for the first 2 years of the proposed action with Delta export reductions implemented beginning in March. Alt2v2 conditions are further analyzed in the Spring Delta Outflow section. Table 125 shows monthly CalSim 3 outputs under Alt2v1 (also referred to as Alt2woTUCPwoVA), which is phase 2 of the proposed action (no VAs), which is likely to occur after the first 2 years of proposed action implementation. Table 126 and Table 127 show monthly CalSim 3 outputs for the NAA and EXP3 respectively.

Table 124. Predicted Old and Middle River flows (cubic feet per second) under Alt2v2 (with reduced export components of Delta voluntary agreements).

Statistic	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
10% Exceedance	-1,837	-1,444	-2,042	-3,109	-1,007	-1,174	-202	-1,511	-1,951	-3,601	-2,753	-3,554
20% Exceedance	-2,202	-2,463	-3,330	-3,522	-3,580	-1,249	-1,093	-1,807	-3,237	-5,192	-3,698	-4,359
30% Exceedance	-2,796	-4,318	-4,193	-3,645	-3,738	-1,485	-1,380	-2,212	-4,306	-7,397	-5,116	-4,591
40% Exceedance	-3,726	-6,230	-5,290	-4,016	-3,941	-1,701	-1,672	-2,682	-4,400	-8,170	-7,576	-5,069
50% Exceedance	-4,693	-7,671	-5,290	-4,262	-4,030	-2,118	-1,821	-2,847	-4,400	-9,161	-8,705	-5,592
60% Exceedance	-5,177	-8,432	-5,290	-4,352	-4,049	-3,011	-2,179	-3,143	-4,475	-9,669	-9,695	-6,501
70% Exceedance	-5,770	-8,723	-5,290	-4,516	-4,223	-3,650	-2,418	-3,400	-4,490	-10,539	-10,366	-6,980
80% Exceedance	-6,129	-9,119	-5,542	-4,625	-4,464	-3,861	-2,996	-3,804	-4,491	-10,901	-10,708	-8,547
90% Exceedance	-7,121	-9,431	-7,395	-4,787	-4,483	-4,281	-3,441	-4,032	-4,505	-11,401	-11,142	-9,768
Full Simulation Period Average	-4,516	-6,229	-4,839	-3,567	-3,190	-2,083	-1,800	-2,667	-3,917	-8,319	-7,662	-6,203
Wet Water Years (28%)	-6,140	-8,522	-5,635	-2,626	-1,995	-1,515	-1,906	-2,778	-4,078	-9,569	-10,067	-7,843
Above Normal Years (14%)	-4,733	-8,613	-5,940	-4,235	-3,757	-1,925*	-1,413*	-3,254*	-4,368	-10,204	-10,550	-6,520
Below Normal Years (18%)	-4,763	-6,415	-4,942	-4,142	-3,838	-1,868*	-2,045*	-2,950*	-4,496	-9,747	-9,632	-6,869
Dry Years (24%)	-3,634	-4,751	-3,713	-4,047	-3,606	-2,844*	-1,851*	-2,464*	-4,214	-7,831	-5,262	-5,342
Critical (16%)	-2,379	-1,705	-4,433	-3,265	-3,436	-2,318	-1,600	-1,943	-2,142	-3,605	-2,613	-3,597

**Amounts with an asterisk (also highlighted in red) show the months and water years where Delta export reductions would occur under the Alt2v2 scenario.*

Source: Table F.2.2-23-2b, Appendix F: Modeling in (U.S. Bureau of Reclamation 2023-2024)

Monthly OMR flows in March to May when Delta VAs are implemented result in a more positive monthly average flow compared to when no VAs (represented by Alt2v1) are implemented (Table 125).

Table 125. Predicted Old and Middle River flows (cubic feet per second) under Alt2v1 (without reduced export components of Delta voluntary agreements).

Statistic	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
10% Exceedance	-1,820	-1,471	-1,998	-3,100	-1,072	-1,225	-1,340	-1,608	-2,225	-3,271	-2,519	-3,458
20% Exceedance	-2,108	-2,458	-3,438	-3,505	-3,580	-3,097	-1,928	-2,116	-3,203	-4,914	-3,142	-4,266
30% Exceedance	-2,731	-4,276	-4,782	-3,645	-3,741	-3,500	-2,307	-2,577	-4,272	-7,293	-4,319	-4,602
40% Exceedance	-3,371	-5,882	-5,290	-3,983	-3,938	-3,500	-2,525	-2,811	-4,400	-8,424	-6,603	-4,985
50% Exceedance	-4,775	-7,665	-5,290	-4,262	-4,030	-3,575	-2,644	-3,069	-4,407	-9,278	-9,118	-5,525
60% Exceedance	-5,109	-8,319	-5,290	–4,346	-4,041	-3,650	-2,993	-3,236	-4,475	-9,703	-9,720	-6,348
70% Exceedance	-5,733	-8,616	-5,290	-4,516	-4,225	-3,905	-3,637	-3,498	-4,490	-10,429	-10,433	-7,218

Statistic	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
80% Exceedance	-6,089	-9,066	-4,406	-4,528	-4,464	-3,905	-3,919	-3,817	-4,491	-11,027	-10,708	-8,534
90% Exceedance	-7,113	-9,359	-7,482	-4,775	-4,489	-4,325	-4,048	-4,011	-4,505	-11,230	-11,141	-9,874
Full Simulation Period Average	-4,447	-6,619	-4,875	-3,551	-3,196	-2,912	-2,671	-2,784	-3,929	-8,182	-7,370	-6,162
Wet Water Years (28%)	-6,124	-8,348	-5,495	-2,637	-1,960	-1,794	-2,802	-2,792	-4,079	-9,618	-10,062	-7,755
Above Normal Years (14%)	-4,731	-8,399	-5,983	-4,235	-3,748	-3,287*	-3,504*	-3,577*	-4,381	-10,244	-10,513	-6,276
Below Normal Years (18%)	-4,523	-6,364	-4,796	-4,119	-3,856	-3,642*	-2,980*	-2,978*	-4,496	-9,852	-8,805	-6,855
Dry Years (24%)	-3,627	-4,820	-3,723	-4,020	-3,617	-3,813*	-2,512*	-2,733*	-4,262	-7,458	-4,620	-5,447
Critical (16%)	-2,253	-1,794	-4,551	-3,209	-3,506	-2,367	-1,606	-1,932	-2,133	-3,072	-2,420	-3,566

**Amounts with an asterisk (also highlighted in red) show the months and water years where Delta export reductions would occur under the Alt2v2 scenario.*

Source: Table F.2.2-23-1b, Appendix F: Modeling in (U.S. Bureau of Reclamation 2023-2024)

Relative to the NAA, OMR flows are close to those expected under the proposed action except in April and May where the proposed action flows are more negative by about 900 cfs. For the EXP3 scenario, OMR flows would be positive the majority of the year (Table 127) since exports do not occur in this scenario.

Table 126. Predicted Old and Middle River flows (cubic feet per second) under the No Action Alternative.

Statistic	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
10% Exceedance	-1,925	-1,645	-1,861	-3,479	-742	-1,679	-636	-1,134	-1,916	-2,127	-2,691	-3,050
20% Exceedance	-2,202	-2,488	-3,226	-3,645	-4,021	-3,286	-892	-1,507	-3,368	-5,624	-3,731	-4,197
30% Exceedance	-2,922	-4,352	-4,683	-3,645	-4,061	-3,500	-1,448	-1,776	-4,355	-7,414	-4,995	-4,530
40% Exceedance	-4,236	-5,530	-5,290	-4,516	-4,144	-3,500	-1,768	-1,909	-4,680	-8,648	-6,707	-4,986
50% Exceedance	-4,869	-7,675	-5,290	-4,516	-4,160	-3,500	-1,996	-2,024	-4,894	-9,465	-9,019	-5,540
60% Exceedance	-5,312	-8,211	-5,290	-4,516	-4,316	-3,500	-2,146	-2,204	-5,000	-10,029	-9,707	-6,335
70% Exceedance	-5,777	-8,579	-5,290	-4,516	-4,415	-3,655	-2,337	-2,363	-5,000	-10,303	-10,284	-7,253
80% Exceedance	-6,202	-9,005	-6,130	-4,852	-4,464	-4,070	-2,434	-2,522	-5,000	-10,793	-10,563	-8,619
90% Exceedance	-7,095	-9,358	-7,473	-5,000	-4,483	-4,070	-3,419	-2,607	-5,000	-11,109	-10,936	-9,093
Full Simulation Period Average	-4,639	-6,178	-4,875	-3,786	-3,268	-2,888	-1,798	-1,825	-4,222	-8,241	-7,465	-5,974
Wet Water Years (28%)	-6,128	-8,400	-5,569	-2,718	-1,706	-1,261	-1,861	-1,095	-4,159	-9,708	-10,116	-7,642
Above Normal Years (14%)	-4,935	-8,399	-5,963	-4,302	-3,528	-3,169	-1,650	-2,348	-4,778	-10,023	-10,386	-5,854
Below Normal Years (18%)	-5,152	-6,123	-4,900	-4,312	-4,100	-3,658	-2,060	-2,114	-4,859	-9,847	-9,043	-6,759
Dry Years (24%)	-3,644	-4,859	-3,704	-4,442	-4,031	-3,933	-2,095	-2,204	-4,796	-8,003	-4,819	-5,490
Critical (16%)	-2,539	-1,982	-4,330	-3,630	-3,692	-3,053	-1,079	-1,748	-2,272	-2,668	-2,463	-3,002

Source: Table F.2.2-23-1a, Appendix F: Modeling in (U.S. Bureau of Reclamation 2023-2024)

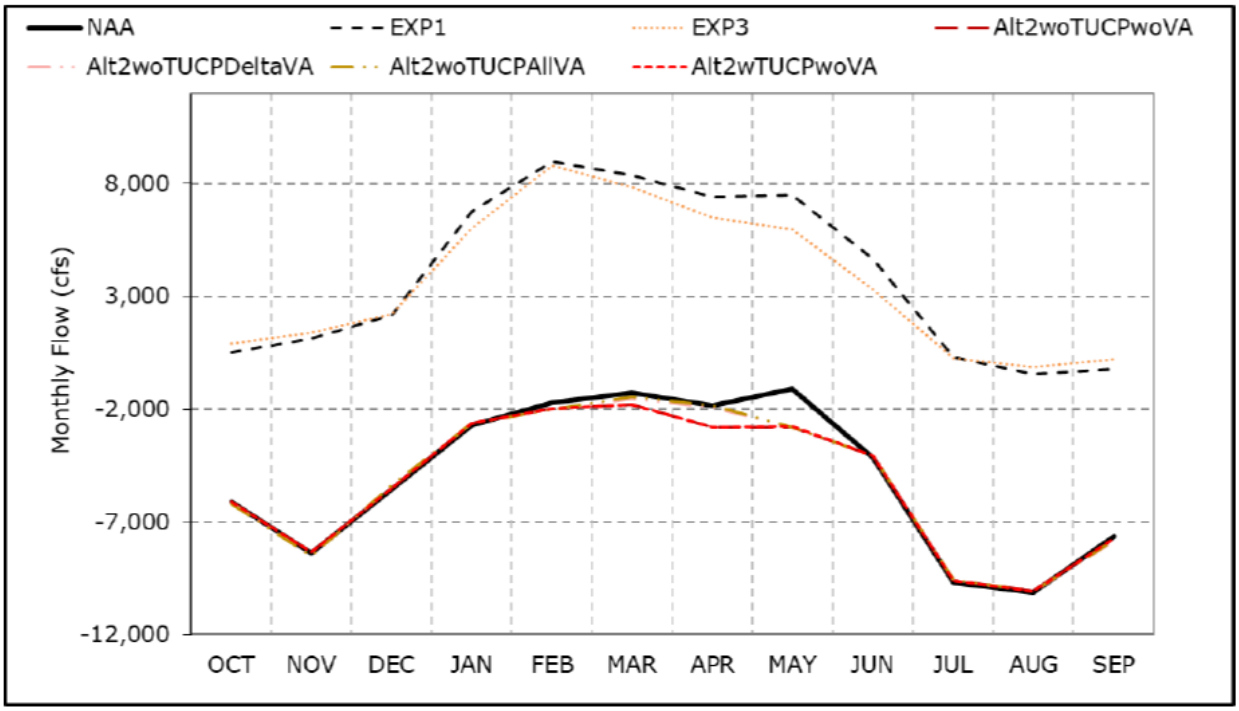
Table 127. Predicted Old and Middle River flows (cubic feet per second) under EXP3 (obligated release scenario).

Statistic	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
10% Exceedance	993	1,480	3,007	5,752	9,810	8,492	7,031	7,203	4,516	310	122	406
20% Exceedance	737	957	1,650	3,364	5,958	5,216	4,096	3,664	1,573	-328	-627	18
30% Exceedance	469	740	1,142	2,418	4,135	4,082	3,035	1,827	494	-640	-715	-321
40% Exceedance	279	587	911	1,825	3,137	2,671	2,242	1,346	-71	-794	-765	-512
50% Exceedance	167	490	746	1,397	1,984	1,687	1,511	801	-316	-887	-871	-585
60% Exceedance	52	403	599	1,097	1,557	1,341	979	294	-474	-1,075	-920	-614
70% Exceedance	-55	300	471	950	1,142	1,113	726	171	-524	-1,131	-972	-654
80% Exceedance	-115	179	375	759	1,028	925	593	16	-569	-1,206	-1,023	-683
90% Exceedance	-172	106	215	622	875	767	532	-54	-704	-1,230	-1,073	-711
Full Simulation Period Average	335	774	1,504	2,746	4,160	3,554	2,830	2,219	789	-642	-674	-327
Wet Water Years (28%)	906	1,373	2,207	6,018	8,808	7,838	6,490	5,983	3,296	236	-119	226
Above Normal Years (14%)	494	624	1,266	2,614	4,368	3,534	2,548	1,636	502	-627	-794	-390
Below Normal Years (18%)	132	631	1,478	1,598	2,593	2,203	1,869	1,199	94	-925	-815	-451
Dry Years (24%)	18	577	1,323	1,117	1,744	1,360	908	373	-462	-1,114	-920	-622
Critical (16%)	-140	288	750	872	1,232	882	635	56	-690	-1,163	-1,009	-656

Source: Table F.2.2-23-5b, Appendix F: Modeling in (U.S. Bureau of Reclamation 2023-2024)

Juvenile salmonids are typically present in the Delta from November to June. The most negative OMR flows are predicted to occur during July and August, when juveniles are least likely to be present. However, during February through May, the proposed action flows are slightly more negative than under current operations, particularly in wet years, with the greatest difference (from NAA) occurring in May (Figure 148). NMFS notes that the CalSim modeling outputs do not reflect the specific spring delta outflow commitment by DWR in the October 2024 proposed action and do reflect a modeling assumption that the spring outflow action starts in mid-March. With the updated commitment from DWR (focused during April and May) and if, during implementation, CVP foregone exports are prioritized in April and May rather than begun in March, NMFS expects OMR flow outcomes under the October 2024 proposed action to be very similar to the NAA.

Figure F.2.2-23-2. Old and Middle River Flow, Wet Year Average Flow



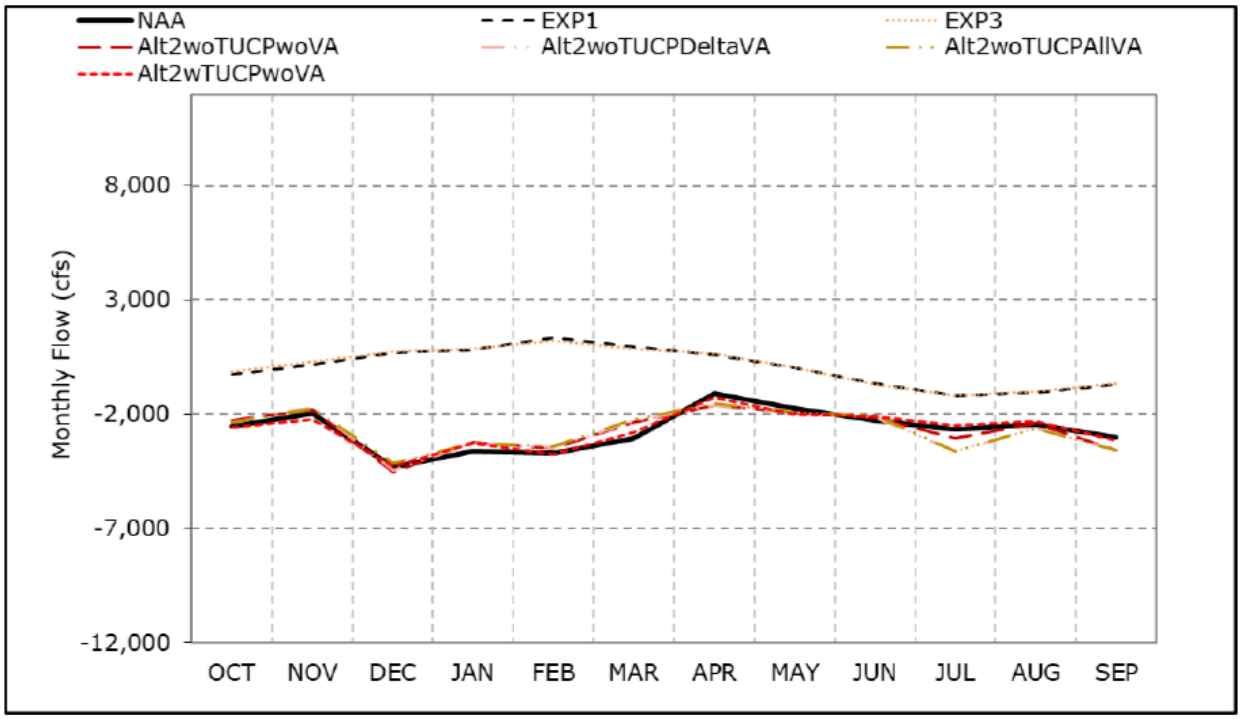
*As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).
*Water Year Types results are displayed with calendar year – year type sorting.
*All scenarios are simulated at 2022 Median climate condition and 15 cm sea level rise.

Figure 148. Monthly average OMR flows during wet years under the proposed action (Alt2woTUCPwoVA [Alt2v1] and Alt2woTUCPDeltaVA [Alt2v2]), the NAA, and EXP3. Alt2woTUCPwoVA and Alt2woTUCPDeltaVA are more negative than EXP3.

Source: Appendix F: Modeling in (U.S. Bureau of Reclamation 2023-2024)

Differences in predicted OMR flows are less discernible during critical water years (Figure 149).

Figure F.2.2-23-6. Old and Middle River Flow, Critical Year Average Flow



*As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).
*"Water Year Types results are displayed with calendar year – year type sorting.
*All scenarios are simulated at 2022 Median climate condition and 15 cm sea level rise.

Figure 149. Old and Middle River flow comparison during critical years showing monthly average flow under the proposed action (Alt2woTUCPwoVA [Alt2v1] and Alt2woTUCPDeltaVA [Alt2v2]), the NAA, and EXP3. The proposed action is slightly more positive than NAA during January and March and slightly more negative in April and May.

Source: Appendix F: Modeling in (U.S. Bureau of Reclamation 2023-2024)

Juvenile SR winter-run Chinook salmon, CV spring-run Chinook salmon, and CCV steelhead peak out-migration all occur during the February through May period. Juvenile sDPS green sturgeon are likely to be present in the Delta year-round. Therefore, all four species would be affected in the months and year types with more negative flows. Implementing Delta VAs (export reductions during March to May of above normal, below normal, and dry water year types) would provide less negative flows for out-migrating juveniles than the Alt2v1 (no VAs) phase of the proposed action which is expected after 2 years.

According to Reclamation's Appendix I (Figure 12, Appendix I_OMR_CWT_Salvage_Model in U.S. Bureau of Reclamation 2023-2024), SR winter-run Chinook salmon have the greatest potential of being salvaged during above normal and wet water year types (Figure 150), where the proposed action would result in a similar level of salvage relative to the NAA modeling scenario in all years. Figure 150 also describes the effect of the first 2 years of Delta VA export reduction, which shows a small decrease in predicted salvage during above normal to dry water year types for the proposed action (Alt2v2) relative to the proposed action without any VA assets (Alt2v1).

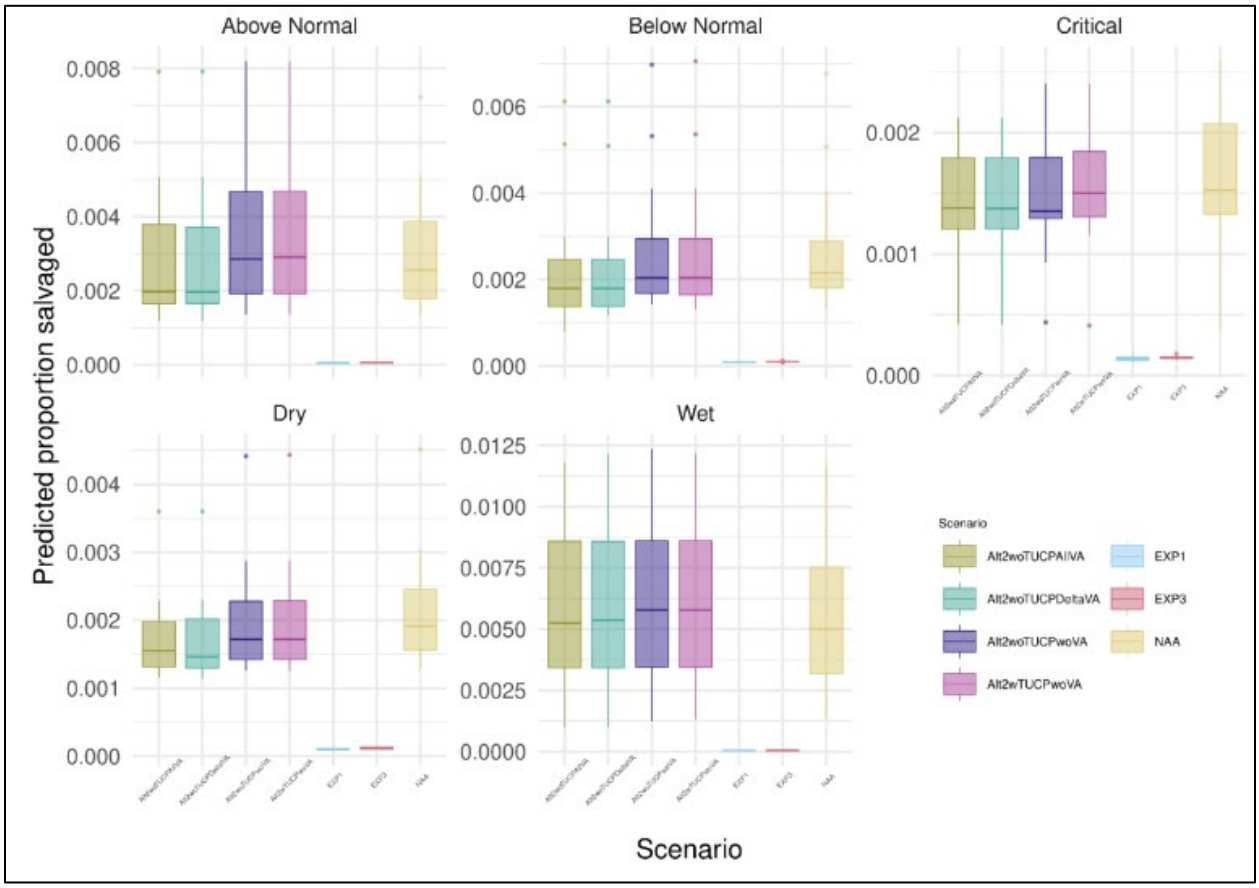


Figure 150. Boxplot of predicted annual proportions of Sacramento River winter-run Chinook salmon salvaged at the Central Valley Project and State Water Project for Alt2 phases, NAA, and EXP3 during different water year types.

Central Valley spring-run Chinook salmon survival to Chipps Island does not appear to vary much under the proposed action scenarios, according to Figure 151 (Figure 14 from OMR Delta Passage Model Appendix, U.S. Bureau of Reclamation 2023-2024). The greatest survival appears to occur during above normal and wet water year types.

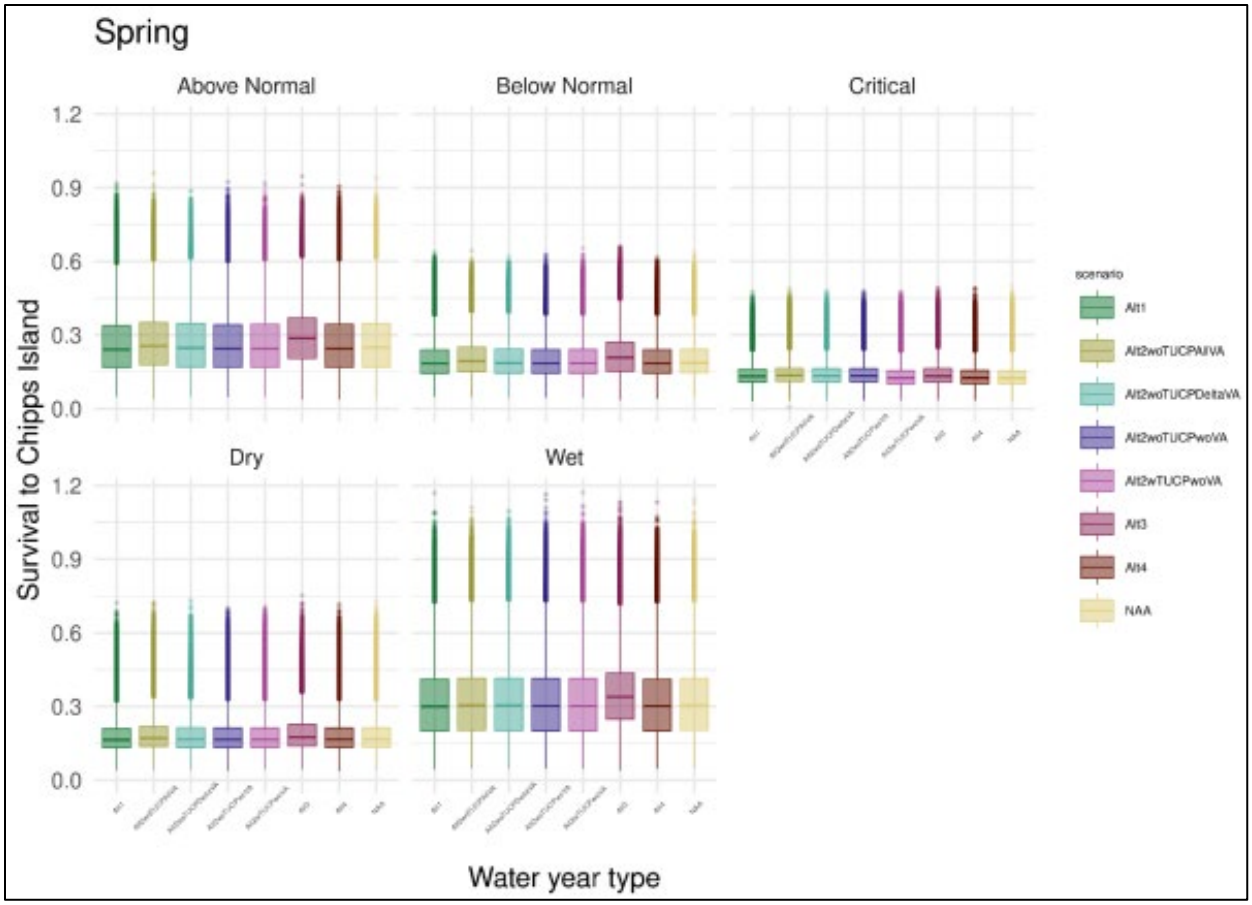


Figure 151. Predicted Central Valley spring-run Chinook salmon survival to Chipps Island averaged by water year type.

Source: (U.S. Bureau of Reclamation 2023-2024)

For the proposed action, the greatest predicted salvage of LAD CV spring-run Chinook salmon is expected to occur during wet water years, and the highest predicted salvage of LAD CV spring-run Chinook salmon is expected to occur from March through May, according to Reclamation's Appendix I - OMR (U.S. Bureau of Reclamation 2023-2024). Generally, across all water year types, combined monthly OMR flows are slightly more negative during April and May and are similar during other months of the year (see Figure 4-66 in the BA [U.S. Bureau of Reclamation 2023-2024]).

Juvenile CCV steelhead would similarly be subjected to entrainment, since their historical peak presence in the salvage facilities primarily occurs in March and April **(**Figure 146).

Southern DPS green sturgeon are presumed to be present year-round, and they are known to spend their first 3 years of life in the Delta. Southern DPS green sturgeon are infrequently salvaged at the SWP and CVP fish facilities and are, therefore, less likely to be entrained at the export facilities than salmonid species. However, NMFS assumes changes in export rates will affect juvenile sDPS green sturgeon in a similar but less severe manner as salmonids.

ESA-listed salmonids and sDPS green sturgeon are likely to respond similarly to changes in OMR flow under the proposed action. Flows are expected to be more negative from February through May, particularly during wet and above normal water years, and similar or more positive during other months. These changes would result in reduced survival of juveniles that are entrained as a result of increased exports, particularly emigrating juvenile salmonids. Implementing Delta VAs (March to May export reductions during above normal, below normal, and dry water year types) would temporarily alleviate this stressor (see Section 7.5.1.7 Spring Delta Outflow).

7.5.1.6.16. Summary of Delta Old and Middle River Flow Management Effects

The proposed action uses a combination of OMR flow management and a metric of historical loss rates. NMFS has determined that this approach is a reasonable way to limit risks associated with the near-field effects (entrainment into and loss) at the export facilities. While there are some uncertainties, such as how operations may change due to the replacement of LAD confirmed fish with genetically confirmed fish, the proposed action includes triggers for review and technical assistance any time observed loss exceeds the average annual historical loss, which provides some assurance that species risks will be conservatively managed.

NMFS assumes that far-field effects are correlated with exports (both footprint and magnitude of hydrodynamic effect greater at higher exports), so limiting near-field effects to historical rates could be assumed to limit far-field effects to historic rates. Modeling results show that OMR (and associated Delta hydrodynamics) will continue to be negative under the proposed action at times when listed species are present.

Under the proposed action, the OMR flow exceedance tables (Table 124 and Table 125; Appendix F in U.S. Bureau of Reclamation 2023-2024) show that OMR flow will be negative (i.e., reverse flow) for all months of the year, with the most negative values from July through November. Under the proposed action without Delta export reductions (Alt2v1), the OMR exceedance tables (Appendix F in U.S. Bureau of Reclamation 2023-2024) show that March to May OMR flow (Table 125) will be more negative than under the proposed action with Delta VA assets (Alt2v2, Table 124) with the most negative values during wet and above normal water years in April and May.

NMFS acknowledges that in some years, especially in drier years, other factors may control OMR and lead to OMR flows more positive than the OMR limits associated with the loss thresholds of the proposed action. For example, the modeling shows that April OMR flows under the proposed action with Delta VAs during critical years are about -1,600 cfs and during wet years were about -1,900 cfs. The modeled OMR averages are more positive than -2,500 cfs for April (averaged over all water year types). Regardless of water year type, May average OMR flows are always more negative than April average OMR flows, but April and May average OMR values for Alt2v1 and Alt2v2 are more positive than -3,500 cfs, except during above normal water years (Appendix F in U.S. Bureau of Reclamation 2023-2024).

NMFS expects the effects to listed salmonids and sDPS green sturgeon to be less adverse during the 2 years of export reductions (Alt2v2) compared to the second phase of the proposed action without VAs implemented (Alt2v1). Regardless of phase, NMFS anticipates reduced survival of juvenile fish due to increased entrainment (from export operations), as well as reduced survival of juvenile fish subjected to more negative OMR flows during their out-migration towards the

ocean. This is expected to impact a large proportion of juvenile SR winter-run Chinook salmon, CV spring-run Chinook salmon, and CCV steelhead. Effects to juvenile sDPS green sturgeon are less certain, but will likely affect individuals in a similar but less severe way.

Table 128 summarizes the individual species analysis of exposure and response associated with the consequences of the proposed action element for operations of the CVP and SWP south Delta export facilities based on Old and Middle River Flow Management.

Table 128. Information used to identify effects of Old and Middle River (OMR) Flow Management on species.

Proposed Action element	Species	Stressors	Life Stage (Location)	Life Stage Timing (Work Window Intersection)	Individual Response and Rationale of Effect	Severity of Stressor	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence
OMR Flow Management	Sacramento River winter-run Chinook salmon	Straying or delayed migration	Adult (Delta)	Nov. - June (Nov. - June)	Altered or delayed migration; increased straying; reduced spawning success	Minor to Sublethal	Small	Low - Infrequent effects extend to migratory corridors	Low	Medium - conceptual understanding of adult migration despite limited monitoring, models to support understanding of Delta hydrodynamics.
OMR Flow Management	Sacramento River winter-run Chinook salmon	Flow (routing), and predation	Juvenile (Delta)	Oct. - April (Oct. - April)	Altered or delayed migration; increased risk to predation, Entrainment; reduced migration success, increased risk of mortality	Sublethal to Lethal	Medium	Low - Infrequent effects extend to migratory corridors	High	High - Multiple studies/publications regarding juvenile survival in various Delta migratory routes; conclusions supported by modeling results.
OMR Flow Management	Central Valley spring-run Chinook salmon	Straying or delayed migration	Adult (Sac. Origin)	Jan. - June (Jan. - June)	Altered or delayed migration; increased straying; reduced spawning success	Minor to Sublethal	Small	Low - Infrequent effects extend to migratory corridors	Low	Medium - conceptual understanding of adult migration despite limited monitoring, models to support understanding of Delta hydrodynamics.

Proposed Action element	Species	Stressors	Life Stage (Location)	Life Stage Timing (Work Window Intersection)	Individual Response and Rationale of Effect	Severity of Stressor	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence
OMR Flow Management	Central Valley spring-run Chinook salmon	Flow (routing), and predation	Juvenile (Sac. Origin)	Young-of-year: Dec. - June (Dec. - June) Yearling: Nov. - Feb. (Nov. - Feb.)	Altered or delayed migration; increased risk to predation, Entrainment; reduced migration success, increased risk of mortality	Sublethal to Lethal	Medium	Low - Infrequent effects extend to migratory corridors	High	High - Multiple studies/publications regarding juvenile survival in various Delta migratory routes; conclusions supported by modeling results.
OMR Flow Management	Central Valley spring-run Chinook salmon	Straying or delayed migration	Adult (San Joaquin Origin)	Jan. - June (Jan. - June)	Altered or delayed migration; increased straying; reduced spawning success	Minor to Sublethal	Large	Medium - Moderate frequency of hydrodynamic alteration in central and south Delta.	Medium	Medium - conceptual understanding of adult migration despite limited monitoring, models to support understanding of Delta hydrodynamics.
OMR Flow Management	Central Valley spring-run Chinook salmon	Flow (routing), and predation	Juvenile (San Joaquin Origin)	Young-of-year: Dec - June (Dec. - June) Yearling: Nov. - Feb. (Nov. - Feb.)	Altered or delayed migration, increased risk to predation, Entrainment; reduced migration success, increased risk of mortality	Sublethal to Lethal	Large	Medium - Moderate frequency of hydrodynamic alteration in central and south Delta.	High	High - Multiple studies/publications regarding juvenile survival in various Delta migratory routes; conclusions supported by modeling results.

Proposed Action element	Species	Stressors	Life Stage (Location)	Life Stage Timing (Work Window Intersection)	Individual Response and Rationale of Effect	Severity of Stressor	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence
OMR Flow Management	California Central Valley steelhead	Straying or delayed migration	Adult (Sac. Origin)	Aug. - May (Nov.- May)	Altered or delayed migration increased straying; reduced spawning success	Minor to Sublethal	Small	Low - Infrequent effects extend to migratory corridors	Low	Medium - conceptual understanding of adult migration despite limited monitoring, models to support understanding of Delta hydrodynamics.
OMR Flow Management	California Central Valley steelhead	Flow (routing), and predation	Juvenile (Sac. Origin)	Dec. - July (Dec. - June)	Altered or delayed migration, increased risk to predation, Entrainment; reduced migration success, increased risk of mortality	Sublethal to Lethal	Medium	Low - Infrequent effects extend to migratory corridors	High	High - Multiple studies/publications re: juvenile survival in various Delta migratory routes; conclusions supported by modeling results.
OMR Flow Management	California Central Valley steelhead	Straying or delayed migration	Adult (San Joaquin Origin)	Aug. - May (Nov.- May)	Altered or delayed migration increased straying; reduced spawning success	Minor to Sublethal	Large	Medium - Moderate frequency of hydrodynamic alteration in central and south Delta.	Medium	Medium - conceptual understanding of adult migration despite limited monitoring, models to support understanding of Delta hydrodynamics.

Proposed Action element	Species	Stressors	Life Stage (Location)	Life Stage Timing (Work Window Intersection)	Individual Response and Rationale of Effect	Severity of Stressor	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence
OMR Flow Management	California Central Valley steelhead	Flow (routing), and predation	Juvenile (San Joaquin Origin)	Dec. - July (Dec. - June)	Altered or delayed migration, increased risk to predation, Entrainment; reduced migration success, increased risk of mortality	Sublethal to Lethal	Large	Medium - Moderate frequency of hydrodynamic alteration in central and south Delta.	High	High - Multiple studies/publications re: juvenile survival in various Delta migratory routes; conclusions supported by modeling results.
OMR Flow Management	sDPS green sturgeon	Delayed migration	Adult (Delta)	June - May (Oct. - May, and June)	Altered migration, Entrainment; reduced spawning success	Minor to Sublethal	Large	Medium - Moderate frequency of hydrodynamic alteration in central and south Delta.	Medium	Low - Limited understanding and monitoring of Delta movement, models to support understanding of Delta hydrodynamics.
OMR Flow Management	sDPS green sturgeon	Flow (routing), and predation	Juvenile/sub-adult (Delta)	June - May (June, and Oct. - May)	Altered migration, Entrainment; reduced growth	Minor to Sublethal	Large	Medium - Moderate frequency of hydrodynamic alteration in central and south Delta.	Low	Low -Limited understanding and monitoring of Delta movement, models to support understanding of Delta hydrodynamics.

7.5.1.7. Spring Delta Outflow

For full details of the Spring Delta Outflow component of the proposed action, see Appendix A of this opinion. In Section 7.5.1 of this opinion (see Table 106), NMFS describes how the Spring Delta Outflow action in the October 2024 proposed action compares to the Spring Delta Outflow action assumptions in the modeling scenarios provided based on the November 2023 proposed action.

As modeled, under the Spring Delta Outflow component of the proposed action, Reclamation and DWR would take actions intended to supplement Delta outflow per the terms of the VAs. However, as there is uncertainty with regard to ultimate implementation of the VAs, and whether the SWRCB will adopt an alternative to the VAs as the final update to the Bay-Delta Water Quality Control Plan, here NMFS analyzes the measures of the pre-adoption of the VAs during the first 2 years of operations, recognizing that the effects could extend longer if the SWRCB has not yet approved the VAs, but substantial progress is being made. Because we cannot expect the operations with the Delta VAs to extend past year 2, we consider the effects of the proposed action with Delta VAs (i.e., Alt2v2) relative to the proposed action without VAs (i.e., Alt2v1). Doing so allows us to identify the magnitude of effects, both positive and negative, that will change if the proposed action is implemented without Delta VAs after year 2. We use this to assess impacts to the population of the ongoing action. For instance, the level of entrainment observed under the proposed action with Delta VAs in years 1 and 2 would be expected to increase in year 3 if the proposed action is implemented without the Delta VAs.

Implementation of the full suite of measures considered in the VAs after the pre-adoption period is dependent on a future action by SWRCB and the VA parties. Because specific details regarding accounting, governance, and other VA program elements are likely to change as they are further refined in the full implementation of the VAs, NMFS is unable to analyze the specific details of where, when, and how the listed species and critical habitat are likely to be affected. Therefore, we analyzed VA implementation after the pre-adoption period (Alt2v3) as a framework programmatic action (see Section 7.9 Programmatic Analysis).

The pre-adoption period of the VAs includes a subset of the measures proposed for full implementation of the VAs consistent with the March 2022 Memorandum of Understanding signed by the VA parties and reflected in Table 3-12 of Section 3.7.5 of Reclamation's BA (U.S. Bureau of Reclamation 2023-2024). This subset of measures and the commitment of flows to support Spring Delta Outflow is included in the proposed action modeling (i.e., Alt2v2) and described in Table 129, which identifies the quantity of export reductions made by Reclamation and DWR by water year type described in Reclamation's modeling Appendix F, Sections 1-1 to 1-3, Attachments 1-1 to 2-11 (U.S. Bureau of Reclamation 2023-2024).

Table 129. Modeled export reductions associated with pre-adoption of the Voluntary Agreements (Delta VAs) as reflected in modeling scenario Alt2v2.

Sacramento Valley (40-30-30) Index Water Year Type	State Water Project Export Reductions (thousand acre-feet)	Central Valley Project Export Reductions (thousand acre-feet)	Combined Export Reductions (thousand acre-feet)
Wet	0	27	27

Sacramento Valley (40-30-30) Index Water Year Type	State Water Project Export Reductions (thousand acre-feet)	Central Valley Project Export Reductions (thousand acre-feet)	Combined Export Reductions (thousand acre-feet)
Above Normal	117.5	147	264.5
Below Normal	92.5	107	199.5
Dry	92.5	86	178.5
Critical	0	3	3

Source: Data from Table 16 and Table 17 of the Alt2v2 description in Section 1-1, CalSim 3, DSM2 and HEC5Q Modeling Simulations and Assumptions of Reclamation's modeling Appendix F (U.S. Bureau of Reclamation 2023-2024).

The narrative description of the pre-adoption of the Delta VAs (i.e., Delta VA modeling) is further described in the modeling appendix (Appendix F in U.S. Bureau of Reclamation 2023-2024) where Reclamation and DWR, after coordination through WOMT, will provide the SWP and CVP a running tally of export reductions, along with other VA parties taking actions similar to those contemplated by the VAs that are expected to result in combined CVP and SWP export reduction totals according to Table 129. Increased Delta outflow from DWR and Reclamation export reductions described above would be in March through May and prioritized during the period of April 1 through May 31. The pre-adoption of the VA actions will continue until the SWRCB updates the Water Quality Control Plan or for 2 years (or longer if they have not been approved but there is substantial progress being made), whichever occurs first. After that time, either the full VAs including the export reductions will be implemented, or the export reductions will cease. Specific operations regarding the timing and volume of export reductions under the Delta VA are modeled according to the following criteria from the Alt2v2 description in Section 1-1, CalSim 3, DSM2 and HEC5Q Modeling Simulations and Assumptions of Reclamation's modeling Appendix F (U.S. Bureau of Reclamation 2023-2024):

- Water year types are determined using a 90-percent exceedance forecast in March–April, and a 50-percent exceedance forecast in May
- All CVP export reductions begin March 10 (when the water year type in the March forecast is determined) and continue through May or until the annual requirement is fully met
- SWP above normal year export reductions begin March 22 and continue through May or until the annual requirement is fully met
- SWP below normal/dry year export reductions begin March 11 and continue through May or until the annual requirement is fully met
- No export cuts when in balanced and In-Basin Use conditions
- SWP export reduction maximum applied in March: 50 TAF in above normal/below normal/dry years
- No export reductions when in balanced and In-Basin Use conditions
- Export reductions restricted to CVP or SWP volume of Unstored Water for Export
- Export reductions restricted to volume of exports above minimum Health and Safety exports, which is 900 cfs (for CVP) and 600 cfs (for SWP)
- Export reductions restricted to volume in CVP or SWP San Luis Reservoir above dead pool

A notable difference between the narrative description of the Delta VAs and the modeling of the Alt2v2 scenario is the prioritization of export reductions in April and May according to the narrative, while the modeling scenario sets the export reductions to begin mid-March. Additionally, as described in Table 106, the October 2024 Proposed Action included some changes in the Spring Delta Outflow element that are not necessarily represented in any of the provided modeling scenarios. Implementation of the Delta VAs through export reductions and the Spring Delta Outflow component of the proposed action is understood to affect the environmental drivers and conditions related to the flow conditions and entrainment in the Delta. Stressors associated with these environmental attributes include:

- Flow conditions, which in the Delta affect routing and through-Delta survival
- Entrainment, the direct estimate of which is considered in salvage and loss calculations

7.5.1.7.1. Species Exposure to Spring Delta Outflow

Species presence in the Delta is summarized in Table 111 in the Presence of the Species Within the Bay-Delta Division section. For the most part, that section lays out the framework for understanding species exposure. This section discusses the more localized exposure of SR winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon to the pre-adoption of the Delta VAs resulting in increased Delta outflow from export reductions described above in March through May and most likely beginning mid-March.

7.5.1.7.1.1. Sacramento River Winter-Run Chinook Salmon

The timing of observations of natural (i.e., non-clipped fish) juvenile SR winter-run Chinook salmon captured in the Sacramento Trawl (Sherwood Harbor) and at the Chipps Island Trawl serve as a proxy for species presence in the Delta where they would be subjected to the increased flows of the Spring Delta Outflow action. As described in Section 7.5.1.2.1, juvenile SR winter-run Chinook salmon are observed in the Sacramento Trawl primarily from November through April, with a bimodal peak passage in December and February/March, based on the LAD criteria (Figure 115, Section 7.5.1.2.1). Examining the Sacramento Trawl observations of unclipped SR winter-run Chinook salmon-sized fish over the last 24 years (1999–2022) indicates that on average, about 90 percent of a cohort will arrive at the Delta by the beginning of March, with 100 percent expected to pass Sherwood Harbor by April 1 (University of Washington Columbia Basin Research 2024a). Sacramento River winter-run Chinook salmon are expected to rear or migrate through the Delta for a relatively short period of time, where on average (1999–2022), 25 percent of LAD SR winter-run Chinook salmon have yet to exit the Delta by April 1, based on Chipps Island Trawl observations (Figure 116, Section 7.5.1.2.1). Given the 25 years of observed LAD SR winter-run Chinook salmon passage into and out of the Delta, NMFS expects that about 25 percent of a year's SR winter-run Chinook salmon cohort would be present in the Delta after April 1 of a given year. NMFS also expects a diminishing proportion of LAD SR winter-run Chinook salmon to be present in the Delta until May 1 when, on average, 100 percent of LAD SR winter-run Chinook salmon have been observed to pass Chipps Island.

7.5.1.7.1.2. Central Valley Spring-Run Chinook Salmon

As described in Section 7.5.1.2.2 and based on Sacramento Trawl observations, juvenile CV spring-run Chinook salmon (young-of-the-year) are present in the Bay-Delta region from

December to May with an average peak passage in late-March and April (Figure 117). NMFS expects 100 percent of juvenile CV spring-run Chinook salmon originating from the Sacramento River basin to enter the Delta by May 15 of each year. Yearling CV spring-run Chinook salmon are expected to enter the Delta in late fall and early winter (late November through January) such that they would not be exposed to the Spring Delta Outflow conditions. Juvenile CV spring-run Chinook salmon are expected to exit the Delta, based on Chipps Island trawl observations, where, over the course of April, 90 percent of CV spring-run Chinook salmon juveniles will exit the Delta (Figure 118, Section 7.5.1.2.2). Based on the average observed passage into and out of the Delta, NMFS expects that close to 100 percent of the CV spring-run Chinook salmon year class originating from the Sacramento River basin would be present in the Delta during the timing of the Spring Delta Outflow operations (March–May).

7.5.1.7.1.3. California Central Valley Steelhead

Juvenile CCV steelhead originating from the Sacramento River generally migrate to the ocean from early winter to early summer, with peak migration through the Delta occurring in March and April (Reynolds et al. 1993). California Central Valley steelhead entering the Delta from the San Joaquin River basin are expected to appear in the southern Delta as early as January. The peak emigration from the Lower San Joaquin River, as observed by the Mossdale trawls near the Head of Old River, occurs from April to May, but with the presence of fish extending from late February to late June. By the beginning of April, about 50 percent of juvenile CCV steelhead have yet to exit the Delta based on Chipps Island trawl observations from 1999–2023 (Figure 120, Section 7.5.1.2.3). Based on the average observed passage into and out of the Delta, NMFS expects that about 50 percent of the CCV steelhead year class would still be present in the Delta during the timing of the Spring Delta Outflow conditions (March–May).

7.5.1.7.1.4. Southern Distinct Population Segment of Green Sturgeon

As described in Section 7.5.1.2.4, the movements of sDPS green sturgeon in the Delta are not well understood. Adults will move out of the Delta into the Upper Sacramento River to spawn in late February through April or even early summer (June/July). Juvenile sDPS green sturgeon will rear in the Delta and migrate to the sea when they are 1 to 4 years old (Moyle et al. 1995). According to Radtke (1966), juveniles were collected year-round in the Delta during a 1-year study in 1963-1964. Based on this limited information, NMFS expects that sDPS green sturgeon exposure to Spring Delta Outflow operations (March–May) would be high.

7.5.1.7.2. Species Response to Spring Delta Outflow

The Spring Delta Outflow action would primarily affect the stressors of Delta water flow and entrainment. These stressors will, in turn, affect a species' routing at junctions in the Delta and, ultimately, through-Delta survival. To estimate the change in flow that will then elicit a species response, NMFS examined the CalSim 3 flow analysis of hydrodynamic changes, comparing monthly OMR Flow and Delta Outflow under the Delta VAs and under the proposed action without TUCPs and without VAs (i.e., Alt2v2-Alt2v1). Table 130 shows the difference in OMR flows (cfs) with Delta VAs compared to the proposed action without VAs. For the proposed action with Delta VAs, there is an increase in net monthly OMR flows, primarily in March and April, of above normal, below normal, and dry water years.

Table 130. Predicted difference in Old and Middle River flows (cubic feet per second) under Alt2v2 compared to Alt2v1.

Water Year Type (proportion of CalSim 3 record)	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Wet Water Years (28%)	-16	-174	130	11	-35	279	896	14	1	49	-5	-88
Above Normal Water Years (14%)	-2	-214	43	0	-9	1,362*	2,091*	323*	13	40	-37	-244
Below Normal Water Years (18%)	-240	-51	-146	-23	18	1,774*	935*	28*	0	105	-557	-14
Dry Water Years (24%)	-7	69	10	-27	11	969*	661*	269*	48	-373	-642	105
Critical Water Years (16%)	-126	89	118	-56	70	49	6	-11	-9	-533	-193	-31

*Spring Delta Outflow.

Source: (U.S. Bureau of Reclamation 2023-2024)

Likewise, Table 131 shows the difference in Delta outflow (cfs) with Delta VAs compared to the proposed action without VAs. For the proposed action with Delta VAs, there is an increase in the monthly Delta outflow in March and April of above normal, below normal, and dry water years.

Table 131. Predicted difference in Delta Outflow (cubic feet per second) under Alt2v2 compared to Alt2v1.

Water Year Type (proportion of CalSim 3 record)	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Wet Water Years (28%)	-14	-25	-26	-301	-118	302	1,002	-73	-22	68	-5	8
Above Normal Water Years (14%)	-5	-67	35	145	8	1,482*	2,196*	259*	-206	243	-2	8
Below Normal Water Years (18%)	-9	19	-200	-134	-249	1,944*	770*	-119*	-26	24	14	46
Dry Water Years (24%)	-33	-75	-114	-197	134	1,071*	552*	190*	-30	21	-26	41
Critical Water Years (16%)	-45	-44	-81	-114	-274	44	-40	2	0	0	0	0

*Spring Delta Outflow.

Source: (U.S. Bureau of Reclamation 2023-2024)

Using the CalSim 3 results, multiple models were used to identify the species responses to the hydrodynamic effects, particularly the following lines of evidence were used to describe the species response:

- OMR Flow Into Junction Analysis
- WRLCM ePTM
- OMR CWT salvage model

- Salvage density

As described in the Delta Effects Lines of Evidence section, a general result of the Flow Into Junctions Analysis using DSM2-HYDRO was that at the Head of Old River, the proportion of flow entering the junction increased as OMR became more negative. For the proposed action with Delta VAs, the monthly OMR flow is less negative than the proposed action without Delta VAs. For the months of March and April of above normal, below normal, and dry water year types, these results suggest that fewer San Joaquin River-origin fish would be entrained into the South Delta relative to the proposed action without VAs. When binned by inflow category, the difference in flow into the Head of Old River junction is a relatively consistent decrease of about 1 percent in South Delta entrainment for operations with Delta VAs.

In considering the species response to a particular operational scenario, the ePTM SSM of the WRLCM is used to estimate changes in Delta survival probabilities by month. Figure 152 shows in above normal, below normal, and dry water years, that although slight, Alt2v2 (Delta VAs) has increased survival in March and April relative to Alt2v1 (the proposed action without VAs). In the month of May, the differences in survival, if any, are small.

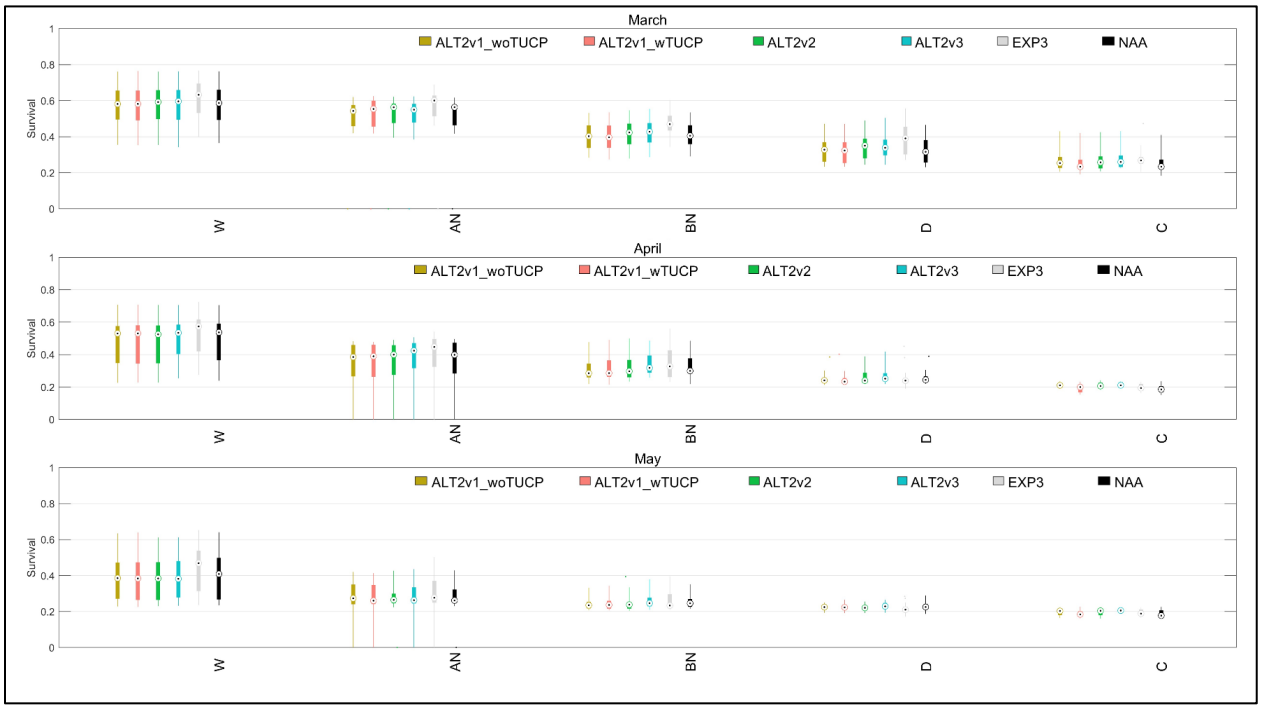


Figure 152. Sacramento River Winter-Run Life Cycle Model results of the Enhanced Particle Tracking Model Smolt Survival Module describing Sacramento River winter-run Chinook salmon Delta survival for March, April, May, water year type, and operational scenario.

Modeling results for the CWT salvage model provide additional detail because they are summarized by month and water year type. Table 132 shows the most relevant data from the analysis examining the predicted monthly proportion of SR winter-run Chinook salmon salvaged

at the export facilities for the months and year types where the Spring Delta Outflow action would be taken. Except for May in below-normal water years, the proposed action with Delta VAs would be expected to reduce the predicted salvage of SR winter-run Chinook salmon by 9 to 55 percent relative to the proposed action without VAs.

Table 132. Coded Wire Tag Salvage Model mean predicted monthly proportion of Sacramento River winter-run Chinook salmon salvaged at the Central Valley Project and State Water Project for alternatives Alt2v1 and Alt2v2 during above normal (AN), below normal (BN), and dry (D) water year types in the months of March, April, and May.

Water Year Type	Month	Alt2v1	Alt2v2	Change in Salvage	% Change in Salvage
AN	March	0.0027	0.0015	0.0012	-44.4%
AN	April	0.0022	0.001	0.0012	-54.5%
AN	May	0.0022	0.002	0.0002	-9.1%
BN	March	0.0025	0.0013	0.0012	-48.0%
BN	April	0.0017	0.0012	0.0005	-29.4%
BN	May	0.0018	0.0018	0	0.0%
D	March	0.002	0.0013	0.0007	-35.0%
D	April	0.001	0.0007	0.0003	-30.0%
D	May	0.001	0.0009	0.0001	-10.0%

Source: Appendix I OMR CWT Salvage Model.pdf in (U.S. Bureau of Reclamation 2023-2024)

Like the CWT Salvage Model, the Salvage-Density model provides estimates of loss densities (fish per TAF of exported water) by month and water year type but also includes differences between species and export facilities. Based on salvage from 2009 to 2022, which is representative of recent salvage patterns, both clipped and unclipped juvenile salmonids are included in the salvage record and are assumed to be representative of the ESU. Table 133 shows the estimated loss of LAD SR winter-run Chinook salmon at the SWP and CVP in the months of March to May for above normal, below normal, and dry water year types. For SR winter-run Chinook salmon identified to race by LAD, the Spring Delta Outflow action would reduce estimated loss at the project export facilities 0 percent (in May of most years at both facilities) to 46.7 percent (in April of above normal years at the SWP). The largest proportional reductions in loss would occur in April, but because of the timing of species presence (e.g., exposure) the largest reduction in loss estimates by number of fish occur in March. The same analysis was used to estimate loss of SR winter-run Chinook salmon based on genetic identification of race, where this analysis had similar results showing a reduction in estimated loss at both export facilities for the proposed action with Delta VAs relative to the proposed action without VAs.

Table 133. Loss of length-at-date Sacramento River winter-run Chinook salmon for above normal (AN), below normal (BN), and dry (D) water year types in March, April and May at A) the State Water Project (SWP) Banks Pumping Plant and B) the Central Valley Project (CVP) Jones Pumping Plant.

A) SWP Banks Pumping Plant (length-at-date Sacramento River winter-run Chinook salmon)

Water Year Type	Month	Alt2v1	Alt2v2	Change in Salvage	% Change in Salvage
AN	March	819	700	119	14.5%
AN	April	75	40	35	46.7%
AN	May	3	3	0	0.0%
BN	March	808	608	200	24.8%
BN	April	73	46	27	37.0%
BN	May	26	26	0	0.0%
D	March	542	447	95	17.5%
D	April	28	19	9	32.1%
D	May	2	2	0	0.0%

B) CVP Jones Pumping Plant (length-at-date Sacramento River winter-run Chinook salmon)

Water Year Type	Month	Alt2v1	Alt2v2	Change in Salvage	% Change in Salvage
AN	March	126	93	33	26.2%
AN	April	3	2	1	33.3%
AN	May	0	0	0	0.0%
BN	March	263	167	96	36.5%
BN	April	47	43	4	8.5%
BN	May	0	0	0	0.0%
D	March	117	94	23	19.7%
D	April	5	4	1	20.0%
D	May	0	0	0	0.0%

The salvage density model was also used to estimate the loss of CV spring-run Chinook salmon at both export facilities, where the estimated loss of CV spring-run Chinook salmon showed a large response to the changes in operations and the foregone exports. Table 134 shows the estimated loss of LAD CV spring-run Chinook salmon at the SWP and CVP in the months of

March to May for above normal, below normal, and dry water year types. For CV spring-run Chinook salmon identified to race by LAD, the Spring Delta Outflow action would reduce estimated loss at the project export facilities from 0.6 percent to 46.2 percent. The largest proportional reductions in loss would occur in April at the SWP and April of above normal water years and March of below normal and dry year types at the CVP, but because of the timing of species presence (e.g., exposure) the largest reduction in loss estimates by number of fish occur in April regardless of export facility.

Table 134. Loss of length-at-date Central Valley spring-run Chinook salmon for above normal (AN), below normal (BN), and dry (D) water year types in March, April, and May at A) the State Water Project (SWP) Banks Pumping Plant and B) the Central Valley Project (CVP) Jones Pumping Plant.

A) SWP Banks Pumping Plant (Central Valley spring-run Chinook salmon)

Water Year Type	Month	Alt2v1	Alt2v2	Change in Salvage	% Change in Salvage
AN	March	1048	895	153	14.6%
AN	April	9818	5283	4535	46.2%
AN	May	22291	19504	2787	12.5%
BN	March	674	507	167	24.8%
BN	April	4480	2811	1669	37.3%
BN	May	2993	2974	19	0.6%
D	March	261	215	46	17.6%
D	April	2891	1917	974	33.7%
D	May	1150	998	152	13.2%

B) CVP Jones Pumping Plant (Central Valley spring-run Chinook salmon)

Water Year Type	Month	Alt2v1	Alt2v2	Change in Salvage	% Change in Salvage
AN	March	197	144	53	26.9%
AN	April	1842	1227	615	33.4%
AN	May	5056	4910	146	2.9%
BN	March	678	430	248	36.6%
BN	April	2280	2067	213	9.3%
BN	May	1158	1124	34	2.9%
D	March	214	171	43	20.1%

Water Year Type	Month	Alt2v1	Alt2v2	Change in Salvage	% Change in Salvage
D	April	1578	1373	205	13.0%
D	May	517	482	35	6.8%

The salvage density model was also used to estimate the loss of CCV steelhead and sDPS green sturgeon at both export facilities. Results for CCV steelhead showed only small differences between modeling scenarios, suggesting a limited species response. Likewise, salvage density modeling estimated no catch of sDPS green sturgeon in the months of March through May, regardless of water year type and operational scenario.

7.5.1.7.3. Summary of Spring Delta Outflow Effects to Individuals

The risk of species being exposed to the Spring Delta Outflow action corresponds to the frequency with which the action would occur. As described in Reclamation's proposed action, the CVP and SWP would implement Delta VA export reductions for the first 2 years in above normal, below normal, and dry water year types with timing and volumes determined by the criteria described in the Spring Delta Outflow section. For the purposes of this action, water year type is determined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (State Water Resources Control Board 1999), where above normal water years are expected to occur in 14 percent of years, below normal water years are expected to occur in 18 percent of years, and dry water years are expected to occur in 24 percent of years. Overall, and according to the Alt2v2 modeling of this action, the effects of the foregone exports related to the pre-adoption Delta VAs are expected to occur in 56 percent of the first 2 years of the proposed action.

Table 135 summarizes the individual species analysis of exposure and response associated with the consequences of the proposed action element of Spring Delta Outflow.

Table 135. Information used to identify effects of the Spring Delta Outflow component of the proposed action.

Stressor	Species and Life Stage (Location)	Life Stage Timing (Work Window Intersection)	Individual Response and Rationale of Effect	Severity of Stressor	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence
Spring Delta Outflow (Flow and routing)	SR winter-run Chinook salmon - Juvenile (Delta)	November - April (March & April)	Routing away from core migration, affecting survival; increased survival	High (+)	Medium (25%)	Medium (56%)	High	Medium
Spring Delta Outflow (Entrainment)	SR winter-run Chinook salmon - Juvenile (Delta)	November - April (March & April)	Salvage/export relationship; increased migration success	Medium (+)	Medium (25%)	Medium (56%)	Medium	High
Spring Delta Outflow (Flow and routing)	CV spring-run Chinook salmon - Juveniles (Delta)	January - June (March - May)	Routing away from core migration, affecting survival; increased survival	High (+)	High (100%)	Medium (56%)	High	Medium
Spring Delta Outflow (Entrainment)	CV spring-run - Juvenile (Delta)	January - June (March - May)	Salvage/export relationship; increased migration success	Medium (+)	High (100%)	Medium (56%)	Medium	High
Spring Delta Outflow (Flow and routing)	CCV steelhead - Juvenile (Delta)	January - June (March - May)	Routing away from core migration, affecting survival; increased survival	High (+)	Medium (50%)	Medium (56%)	High	Medium
Spring Delta Outflow (Entrainment)	CCV steelhead - Juveniles (Delta)	January - June (March - May)	Salvage/export relationship; increased migration success	Medium (+)	Medium (50%)	Medium (56%)	Medium	High
Spring Delta Outflow (Entrainment)	Green Sturgeon Juveniles (Delta)	Year-round (March - May)	Salvage/export relationship; increased migration success	Medium (+)	High (100%)	Medium (56%)	Medium	High

7.5.1.8. Delta Smelt Summer and Fall Habitat

7.5.1.8.1. Fall X2

Reclamation and DWR will maintain a 30-day average X2 less than or equal to 80 kilometers for September through October in order to increase the amount of low salinity zone habitat for Delta smelt in wet and above normal hydrologic year types.

7.5.1.8.2. Suisun Marsh Salinity Control Gates

The Suisun Marsh Salinity Control Gates (SMSCG) are located on Montezuma Slough about 2 miles downstream of the confluence of the Sacramento and San Joaquin rivers, near Collinsville, California. The SMSCG spans the 465-foot width of Montezuma Slough. The facility consists of three radial gates, a boat lock structure, and a maintenance channel that is equipped with removable flashboards. When the SMSCG is in operation, the flashboards are installed at the maintenance channel and the gates are operated tidally.

The purpose of gate operation is to decrease the salinity of the water in Montezuma Slough to meet salinity standards set by the SWRCB and Suisun Marsh Preservation Agreement. The SMSCG controls salinity by lowering gates during flood tides to prevent the flow of higher salinity water from Grizzly Bay into Montezuma Slough and opening gates during ebb tides to retain the lower salinity Sacramento River water that entered the marsh during the previous ebb (outgoing) tide. Currently, SMSCG operations occur from October to May (approximately 10 to 20 days) and June through October for up to 60 days during above normal and below normal water years, where radial gates are lowered during the flood tides and opened during the ebb tides, flashboards are in place through September, and a boat lock is operated as-needed for passing vessels. The boat lock portion of the gate is held open at all times during SMSCG operations to allow for continuous Chinook salmon passage opportunities. However, the boat lock gates may be closed temporarily to stabilize flows to facilitate safe passage of watercraft through the facility. Outside of the period, the radial gates remain open, flashboards are removed, and operation of the boat lock is not needed.

To evaluate the potential effects of the SMSCG operations on adult salmonid passage, telemetry studies were conducted on adult Chinook salmon starting in 1993. In seven different years (1993, 1994, 1998, 2001, 2002, 2003, and 2004), migrating adult fall-run Chinook salmon were tagged and tracked by telemetry in the vicinity of the SMSCG. These studies showed that the operation of the SMSCG delays passage of some adult Chinook salmon, while other adult Chinook salmon never pass through the SMSCG and instead swim downstream for approximately 30 miles to Suisun Bay and then access their natal Central Valley streams via Honker Bay. Based on the results of studies, CDFG (now CDFW) recommended modifications to the structure to improve passage (Edwards et al. 1996, Tillman et al. 1996). In 1998, modifications were made to the flashboards at the SMSCG maintenance channel to include two horizontal openings, but telemetry monitoring indicated that the modified flashboards did not improve Chinook salmon passage (Vincik et al. 2003). Telemetry studies conducted in 2001, 2002, 2003, and 2004 evaluated the use of the existing boat lock as a fish passageway. These results indicated that fish passage improved when the boat lock was opened. Successful passage rates improved by 9, 16, and 20 percent in 2001, 2003, and 2004, respectively, when compared to full SMSCG operations with the boat lock closed. In addition, opening of the boat lock reduced mean passage time by 19

hours, 3 hours, and 33 hours in 2001, 2003, and 2004, respectively. The 2002 results did not confirm these findings, but equipment problems at the structure during the 2002 season likely confounded the 2002 fish passage studies (Vincik et al. 2003).

To address effects on critical habitat for juvenile Delta smelt and increase habitat and food access for Delta smelt in summer and fall (June through October) in Suisun Marsh and Grizzly Bay during above normal, below normal, and dry years following wet or above normal years, DWR will operate SMSCG for 60 days, to maximize the number of days that Belden's Landing three-day average salinity is equal to, or less than, 4 practical salinity units (psu).

Operation of the SMSCG will occur between June 1 and October 31 in years in which operation of the SMSCG is required. In dry years following below normal years, DWR will operate SMSCG for 30 days to maximize the number of days Belden's Landing three-day salinity is equal to, or less than 6 psu to maximize the spatial and temporal extent of Delta smelt low salinity zone habitat in Suisun Marsh and Grizzly Bay. DWR and Reclamation, through the Delta Coordination Group (DCG), may prepare an assessment to propose an alternative gate operation if modeling of hydrological and/or existing D-1641 conditions indicate the action can achieve the same habitat benefits in an equal or better manner within the range of effects analyzed. Subsequently, DWR and Reclamation may propose alternative operations of the SMSCG for WOMT to consider prior to May 15 of each year a SMSCG action will be required.

NMFS assumes the boat lock will be operated as described in the 2019 BA (U.S. Bureau of Reclamation 2019b), which states the SMSCG are held open at all times during SMSCG operations to allow for continuous salmonid passage opportunities. During the summer and early fall months, listed fish species are less likely to be present. However, adult and juvenile CCV steelhead and sDPS green sturgeon are known to be present in the Delta during some or all of these months.

7.5.1.8.2.1. Summary of Delta Smelt Summer and Fall Habitat Effects to Listed Salmonid Individuals

The principal potential effect of the SMSCG being closed for up to 20 days per year from October through May, plus an additional 30 to 60 days per year from June to October, is the delay of upstream-migrating adult SR winter-run Chinook salmon, CV spring-run Chinook salmon, and CCV steelhead that have entered Montezuma Slough from its westward end, and are seeking to exit the slough at its eastward end. del Rosario et al. (2013) found some evidence that opening the boat lock improved passage rates of acoustically tagged adult Chinook salmon; however, even with the gates opened, approximately 30 to 40 percent of fish returned downstream. Adult salmonids that do not continue upstream past the SMSCG are expected to return downstream by backtracking through Montezuma Slough to Suisun Bay, and they likely find the alternative upstream route to their natal Central Valley streams through Suisun and Honker bays (California Department of Water Resources and California Department of Fish and Game 2005).

During the majority of the period from October to May, the SMSCG will not be operated and no fish passage delays due to the gates are anticipated. However, during the annual 10 to 20 days of periodic operation in October to May, and the 30 to 60 days in June to October, individual adult salmonids may be delayed in their spawning migration from a few hours to several days. The

effect of this delay is not well understood. Sacramento River winter-run Chinook salmon are typically several weeks or months away from spawning and, thus, they may be less affected by a migration delay in the estuary. California Central Valley steelhead migrate upstream as their gonads are sexually maturing and a delay in migration may negatively impact their reproductive viability. Central Valley spring-run Chinook salmon are typically migrating through the estuary several months before spawning, but an extended delay in the estuary may affect their ability to access their natal spawning streams. Central Valley spring-run Chinook salmon generally utilize high streamflow conditions during the spring snowmelt to assist their upstream migration. Rapid upstream movement may be needed to take advantage of a short-duration high-stream flow event, particularly in dry years when high-flow events may be uncommon. If the destination of a pre-spawning adult salmon or CCV steelhead is among the smaller tributaries of the Central Valley, it may be important for migration to be unimpeded, since access to a spawning area could diminish with receding flows.

Operations during the months of June to October are expected to have a minimal impact on adult and juvenile CCV steelhead that may be present during that time. However, the boat lock portion of SMSCG is held open at all times during SMSCG operations to allow for continuous salmonid passage opportunities. Therefore, the potential for negative near-field effects on downstream-migrating juvenile salmonids would be limited. Adult salmonids are at risk of delay if encountering closed SMSCG while the boat lock is closed for vessel passage, but salmonids could backtrack around the structure. CV spring-run Chinook salmon and CCV steelhead would likely experience greater negative effects than SR winter-run Chinook salmon, because CV spring-run Chinook salmon and CCV steelhead are more reliant on short-term high flow events in smaller tributaries to provide access to suitable spawning habitat.

Salmonid smolt predation by striped bass and pikeminnow could be exacerbated by operation of the SMSCG. These predatory fish are known to congregate in areas where prey species can be easily ambushed. Pikeminnow are not typically major predators of juvenile salmonids (Brown and Moyle 1981), but both pikeminnow and striped bass are opportunistic predators that will take advantage of localized, unnatural circumstances. The SMSCG provides an enhanced opportunity for predation because fish passage is blocked or restricted when the structure is operating. However, DWR proposes to limit the operation of the SMSCG to only periods required for compliance with salinity control standards, and this operational frequency is expected to be 10 to 80 days per year, and most of these days are during the summer. A small proportion of adult SR winter-run and CV spring-run Chinook salmon may be present during the month of June and are unlikely to be present from July through October. Adult CCV steelhead are typically present in the Delta during late-summer. Juvenile salmonids are not likely to be present from July to October. In addition, most listed CV salmonid smolts reach the Delta as yearlings or older fish. Since the size and type of prey taken by pikeminnow varies with the size and age of the fish (Brown and Moyle 1981), the relatively large body size and strong swimming ability of listed salmon and steelhead smolts reduce the likelihood of being preyed upon.

7.5.1.8.2.2. Summary of Delta Smelt Summer and Fall Habitat Effects to the Southern Distinct Population Segment of Green Sturgeon Individuals

Little is known about adult sDPS green sturgeon upstream passage at the SMSCG, with existing studies suggesting that Suisun and Honker bays are more utilized than Montezuma Slough,

where the SMSCG is located. NMFS anticipates that adult sDPS green sturgeon would have the opportunity to pass the SMSCG through the boat lock or gates (when open), as adult salmonids do, but that they could be delayed.

Adult sDPS green sturgeon migrate into the Delta from the Pacific Ocean in the late winter months into early spring (January through early March) to spawn in the Sacramento River and its tributaries in spring to early summer (April through July). Southern DPS green sturgeon spawn in the deep, turbulent sections of the upper reaches of the Sacramento River, and spring stream flows in the mainstem Sacramento River are generally not limiting their upstream migration. It is also common for sDPS green sturgeon to linger for several days in the Delta prior to initiating their active directed migration to the Upper Sacramento River. After spawning, adult sDPS green sturgeon normally hold in the rivers before leaving the system in two main out-migration patterns, one in June/July and another in September/October, dependent on the discharge and outflow of water that triggers them. Out-migrating sDPS green sturgeon adults are unlikely to be affected by the SMSCG since the gates will be open during their migration to the Pacific Ocean.

Juvenile sDPS green sturgeon rear in the Delta and San Francisco Estuary before migrating to the Pacific Ocean when they are 1 to 4 years old (Moyle et al. 1995). Juveniles are collected year-round in the Delta, but there is a higher presence of juvenile sDPS green sturgeon during the spring and summer months (reported by the export facilities located in the South Delta). The potential for predation near the SMSCG that was previously discussed for juvenile salmonids would be of minimal concern for juvenile sDPS green sturgeon because they are relatively large and unlikely prey for striped bass and Sacramento pikeminnow. In addition, the multi-year estuarine residence of juvenile sDPS green sturgeon often includes long periods of localized, non-directional movement interspersed with occasional long-distance movements (Kelly et al. 2007), and such movements are unlikely to be negatively affected by periodic delays ranging from a few hours to a few days at the SMSCG.

Table 136 summarizes the individual species analysis of exposure and response associated with the consequences of the proposed action element Delta Smelt Summer and Fall Habitat.

Table 136. Information used to identify effects of the proposed action from Delta Smelt Summer and Fall Habitat on species.

Proposed Action element	Species	Stressors	Life Stage (Location)	Life Stage Timing (Work Window Intersection)	Individual Response and Rationale of Effect	Severity of Stressor	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence
Operation of Suisun Marsh Salinity Control Gates	Sacramento River Winter-run Chinook salmon	Straying or delayed migration	Adult (W. Delta)	Nov. - June (Nov. - May and June)	Altered or delayed migration increase to straying; reduced spawning success	Minor to Sublethal	Medium (7% - 12%)	Medium, gates operated annually and under certain conditions.	Low	Medium - Multiple studies/ publications re: adult salmonid migration and Suisun Marsh Salinity Control Gate operations.
Operation of Suisun Marsh Salinity Control Gates	Central Valley spring-run Chinook salmon	Straying or delayed migration	Adult (W. Delta)	January - June (Jan. - May, and June)	Altered or delayed migration increase to straying; reduced spawning success	Minor to Sublethal	Medium (8% - 15%)	Medium, gates operated annually and under certain conditions.	Low	Medium - Multiple studies/ publications re: adult salmonid migration and Suisun Marsh Salinity Control Gate operations.
Operation of Suisun Marsh Salinity Control Gates	California Central Valley steelhead	Straying or delayed migration	Adult (W. Delta)	Aug. - May (Aug. - Sept. and Oct. - May)	Altered or delayed migration increase to straying; reduced spawning success	Minor to Sublethal	Medium (8% - 17%)	Medium, gates operated annually and under certain conditions.	Low	Medium - Multiple studies/ publications re: adult salmonid migration and Suisun Marsh Salinity Control Gate operations.

Proposed Action element	Species	Stressors	Life Stage (Location)	Life Stage Timing (Work Window Intersection)	Individual Response and Rationale of Effect	Severity of Stressor	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence
Operation of Suisun Marsh Salinity Control Gates	sDPS green sturgeon	Delayed migration	Adult (W. Delta)	Jan. - March (Jan. - March)	Altered migration; reduced spawning success	Minor to Sublethal	Medium (4% - 8%)	Medium, gates operated annually and under certain conditions.	Low	Low - Limited studies/ publications re: adult sturgeon migration and Suisun Marsh Salinity Control Gate operations.

7.5.1.9. Tracy Fish Collection Facility

The Tracy Fish Collection Facility is located in the southwest portion of the Sacramento-San Joaquin Delta near the cities of Tracy and Byron. It uses behavioral barriers consisting of primary and secondary louvers to guide entrained fish into holding tanks before transport by truck to release sites within the Delta. The original design of the Tracy Fish Collection Facility focused on smaller fish (less than 200 millimeters) that would have difficulty fighting the strong pumping plant-induced flows, since the intake is essentially open to the Delta and also impacted by tidal action.

The primary louvers are located in the primary channel just downstream of the trash rack structure. The secondary traveling screens (hydrolox screens) are located in the secondary channel just downstream of the primary bypasses. The primary louvers allow water to pass through into the main Delta-Mendota intake channel and continue towards the Bill Jones Pumping Plant located several miles downstream. However, the openings between the louver slats are tight enough and angled against the flow of water in such a way as to prevent most fish from passing between them and, instead, guide them into one of four bypass entrances positioned along the louver arrays. The efficiency of the louver guidance array is dependent on the ratio of the water velocity flowing into the bypass mouth and the average velocity in the main channel sweeping along the face of the louver panels.

When South Delta hydraulic conditions allow, and within the original design criteria for the Tracy Fish Collection Facility, the louvers are operated with the D-1485 objectives of achieving water approach velocities for striped bass of approximately 1 foot per second from May 15 through October 31 and for salmon of approximately 3 feet per second from November 1 through May 14. Channel velocity criteria are a function of bypass ratios through the facility. Louver efficiency at the Tracy Fish Collection Facility is dependent on the flow and velocities, fish species, and the fish size (life stage). The number of pumps (units) running at the Jones Pumping Plant dictates the flow and velocity at the Tracy Fish Collection Facility. There are six units at Jones Pumping Plant, but a maximum of five units can be used; each unit increases the velocity through the Tracy Fish Collection Facility primary channel about 0.5 feet per second. For juvenile Chinook salmon, whole facility efficiency evaluations completed using acoustic tag telemetry suggests that primary louver efficiency ranges from 50 to 100 percent with an average of approximately 88.7 percent (Karp et al. 2017, Wu and Fullard 2018). At higher pumping regimes of 4 to 5 units at Jones Pumping Plant, for juvenile Chinook salmon, louver efficiency was high at 71.4 to 100 percent (Karp et al. 2017).

(Sutphin and Bridges 2008) has indicated that under the low pumping regimen required by the Vernalis Adaptive Management Plan experiment, primary louver efficiencies (termed capture efficiencies in the report since only one bypass was tested) can drop to less than 35 percent at the Tracy Fish Collection Facility. The reductions in pumping create low velocities in the primary channel, and the necessary primary bypass ratios (greater than 1) cannot be maintained simultaneously with the secondary channel velocities (3.0 to 3.5 feet per second from February 1 through May 31) required under D-1485. These study results indicate that loss of fish can potentially increase throughout the entire louver system if the entire system behaves in a similar way as the test section performed in the experiments.

Screening efficiency for juvenile sDPS green sturgeon is unknown, although somewhat effective given that green sturgeon, as well as white sturgeon, have been collected during fish salvage operations. Studies by Kynard and Horgan (2001) tested the efficiency of louvers at guiding yearling shortnose sturgeon (*Acipenser brevirostrum*) and pallid sturgeon (*Scaphirhynchus albus*) under laboratory conditions. They found that louvers were 96 to 100 percent efficient at guiding these sturgeon species past the experimental array and to the flume bypass. However, both sturgeon species made frequent contacts with the louver array with their bodies while transiting along the louver array. The authors also found that sturgeon would rest at the junction between the louver array and the tank bottom for extended periods. This behavior may degrade the effectiveness of the louver array to guide fish towards the bypass.

"Pre-screen loss rate" is defined as "the rate of loss to entrained salmon during movement from the trash racks to the primary louvers" (Aasen 2013). In essence, the "pre-screen loss rate" is the predation rate within the primary channel. Although Chinook salmon mortality has been observed in front of the Tracy Fish Collection Facility trash rack (Vogel 2010), this mortality is not included in the pre-screen loss calculation since this is outside of the area between the trash rack and primary louvers. Currently, a 15 percent pre-screen loss rate due to predation is an agreed upon placeholder value but has yet to be fully verified. For this placeholder, the predation rate within the primary channel is currently being verified with the use of Predation Detection Acoustic Tags.

Prescreen loss at the Tracy Fish Collection Facility is dependent on fish species, fish size (life stage), and predator load within the primary channel. In addition, it appears that prescreen loss may be inversely correlated with pumping rates (water velocity) and/or turbidity, although more data need to be collected to adequately determine these relationships. Data from Karp et al. (2017) and Wu and Fullard (2018) suggest that prescreen loss ranges from 0 to 40 percent for juvenile Chinook salmon. Low estimates of pre-screen loss (assuming all unknown fates in the primary channel are non-participants) from these studies average approximately 14.0 percent, while high estimates of prescreen loss (assuming all unknown fates in the primary channel are losses to predation) average approximately 15.9 percent. Therefore, preliminary results indicate that the predation rate (or prescreen loss) may be close to the 15 percent placeholder value mentioned above (Karp et al. 2017, Wu and Fullard 2018). One mechanism of reducing predation is to flush predators—especially a prevalent piscivorous predator, striped bass—from the bypass pipes and secondary channel into the holding tanks using carbon dioxide in the form of dry ice (Wu et al. 2023). As described in "APPENDIX____.TFCF Fish Handling Operations Manual" (U.S. Bureau of Reclamation 2023-2024), carbon dioxide predator flushes are conducted on a monthly basis.

The current primary louver cleaning procedures and operations involve lifting each individual louver panel, 36 total, out of the water in order to spray wash the debris. The frequency of cleaning may be increased or decreased according to pumping rate and debris loads.

Loss due to cleaning is not quantified in the current loss calculation, so the reported loss is chronically underestimated. Reclamation estimates that approximately 6.7 percent of juvenile Chinook salmon that encounter the louvers are lost through the louvers when they are lifted for cleaning, and approximately 33.3 percent of louver loss occurs during louver cleaning activity (Karp et al. 2017). This value, however, is preliminary and needs further verification.

Fish salvage occurs at the Tracy Fish Collection Facility year-round, except during temporary outages and maintenance activities. Pumping typically continues during a salvage outage. Fish are maintained in these holding tanks for 8 to 24 hours, depending on the species of fish that are being salvaged, the number of fish salvaged, and debris load. The number of fish that are salvaged in Tracy Fish Collection Facility holding tanks is generally estimated by performing a 30-minute fish-count subsample for every 120 minutes. "APPENDIX____.TFCF Fish Handling Operations Manual" from the BA (U.S. Bureau of Reclamation 2023-2024) describes a process in which fish-count minutes represent 25 percent of pumping minutes, but Reclamation has since clarified that their actual practice (which will be updated in a future operations manual) is to implement fish-count minutes as 25 percent of salvage operations minutes. The number of each species of fish collected in the subsample is determined and then multiplied by 4 (120 salvage operation minutes/30-minute fish-count subsample = expansion factor of 4) to estimate the total number of each species of fish, as well as the total number of fish, that were salvaged in Tracy Fish Collection Facility holding tanks during the 120-minute salvage operation period. Salvage operation minutes and fish-count minutes could potentially deviate from 120 minutes and 30 minutes, respectively, which would change the expansion factor used to estimate total fish salvage. This is typically done when the numbers of fish salvaged are high or there is heavy debris loading in the holding tanks.

Loss during a temporary salvage outage (but while export operations continue) is not quantified in the current loss equation. While more sporadic than the underestimation due to louver cleaning, disruption to salvage operations does contribute to underestimates of loss. While a 2 to 6-hour disruption is a small fraction of the annual salvage operations, it represents a one-twelfth to one-quarter of a day gap in loss estimation. This disruption could be significant during periods of higher presence of listed fish or when nearing a loss threshold that may trigger an operational change, for example, to OMR management. NMFS acknowledges that the current loss thresholds were developed based on historical loss data, which include sources of underestimation due to louver cleaning and salvage outages. The Alternative Loss Pilot Study Implementation Plan (ALPS-IP), analyzed in the section for Programmatic Actions, is a proposed action element that is intended to help improve loss estimation and quantification of take at the export facilities and could address some of these limitations of the current loss estimation method.

If no Chinook salmon, steelhead, or Delta smelt are salvaged, other species of fish can be maintained in Tracy Fish Collection Facility holding tanks for up to 24 hours. If a Chinook salmon or steelhead is collected during fish counts, fish can only be maintained in Tracy Fish Collection Facility holding tanks for up to 12 hours. If a Delta smelt is collected during a fish count, salvaged fish may only be held in Tracy Fish Collection Facility holding tanks for up to 8 hours. The frequency of fish hauls is also dictated by the Bates Tables, which uses numbers of fish, size classes, species, and water temperature as indicators for when to conduct a fish haul.

During normal operations, salvaged fish are transported and released at one of two currently operational Reclamation release sites near the confluence of the Sacramento and San Joaquin rivers (Antioch Fish Release Site and Emmaton Fish Release Site). With the permission of DWR, fish may also be released at any of four SWP-owned release sites. Reclamation will continue transporting salvaged fish to release sites with injected oxygen and 8 ppt salt solution to reduce stress. Upon arrival at release sites, operators measure certain important water quality parameters (dissolved oxygen, salinity, and temperature) prior to releasing fish. This is done to

verify that water quality parameters remain acceptable during fish transport. Salmon loss due to handling and trucking are generally low and are based on CDFW trucking and handling studies. The loss equation assumes that loss associated with handling and trucking is 2 percent for salmon smaller than 100 millimeters and 0 percent for salmon larger than 100 millimeters (Aasen 2013). Fullard et al. (2018) estimated that the "survival of salvaged fish at Delta release sites is likely dependent on water temperature, seasonal predator and prey assemblage variability, diurnal behavioral changes, frequency of site-specific releases (e.g., number of releases per day), tides, river discharge, and total abundance of fish in each release."

Miranda and Padilla (2010) conducted a release site predation study from 2007 to 2008, which concluded predation of salvaged fish is due to predatory fishes remaining near the release sites when the number of fish being released is consistently high. In addition, salvaged fish were also vulnerable to bird predation when released during daylight hours. Overall, the study determined that predation at release could have a substantial effect on salvaged fish survival. Estimates of post-release predation rates given by DWR range from 10 percent to 30 percent for juvenile salmonids, depending on the density of predators at the release site and the number of fish released per episode (Orsi 1967, Pickard et al. 1982, Earley et al. 2009). Estimates are crude and several potential biases in the earlier studies are present, including net sampling efficiency, susceptibility of predators to capture, and estimation of predator populations within the study area. Recent evidence obtained using acoustic imaging equipment (DIDSON cameras) has shown that predators are quickly attracted to the discharge pipelines upon the startup of the priming water flow, indicating a learned response to the discharge of salvaged fish at the release sites. Since salvage of listed fish primarily occurs to juveniles or smolt-sized fish, it is this life stage that is most affected by the collection, handling, trucking, and release process. Hammen et al. (2021) reported that altering the frequency from a salvage release every day (perhaps more predictable to local predatory fish) to a salvage release every fifth day did not reduce relative predation rates, but that relative predation rates were lower during dawn and dusk and with deeper water releases.

It is anticipated that loss to predation is the main source of post-release mortality. Salvage and operations data necessary to calculate loss are made available daily by 10 a.m. for the previous day. The standard operating procedures for the Tracy Fish Collection Facility are included in "APPENDIX____. TFCF Fish Handling Operations Manual" (U.S. Bureau of Reclamation 2023-2024).

Reclamation will operate the Tracy Fish Collection Facility to screen fish from the Jones Pumping Plant. The primary channel is a behavioral barrier with effectiveness that depends on the pumping at Jones Pumping Plant. The secondary channel is a positive fish barrier. When South Delta hydraulic conditions allow and conditions are within the original design criteria for the Tracy Fish Collection Facility, the secondary channel is operated to achieve water approach velocities for striped bass of approximately 1 to 2.5 feet per second from June 1 through October 31 and for salmon of approximately 3 feet per second from November 1 through May 31.

Removal of predatory fish will continue under the proposed action to limit fish loss due to predation and to improve fish salvage efficiency. Carbon dioxide treatment is used for the predator removal to flush all fish residing in the bypass pipes, secondary channel, and holding tank conduit on a monthly basis.

Larval smelt sampling commences upon detection of a spent female at Tracy Fish Collection Facility or Skinner Delta Fish Protective Facility or when a temperature trigger of 53.6°F (12°C) at nearby California Data Exchange Center stations is met. Salvage and operations data necessary to calculate loss are made available daily by 10 a.m. The standard operating procedures for the Tracy Fish Collection Facility are included in "APPENDIX____. TFCF Fish Handling Operations Manual" (U.S. Bureau of Reclamation 2023-2024).

7.5.1.9.1. Alternative Loss Equation

The current loss equation underestimates loss because (1) the calculation/conversion of salvage to loss does not incorporate additional loss as a result of primary louver cleaning, and (2) exports often continue during Tracy Fish Collection Facility salvage operation outages.

To seek additional improvements to the operating procedures and reporting of the Tracy Fish Collection Facility, Reclamation proposes to develop the Alternative Loss Pilot Study Implementation Plan and to implement the resulting pilot study. The pilot study would include consideration of additional salvage facility loss parameterization and is expected to improve the accuracy and reliability of data and fish survival. For more details about and evaluation of the Alternative Loss Pilot Study Implementation Plan, See Section 3.11.11 in the full-text proposed action in Appendix A and Section 7.9.1.4 (Adaptive Management Actions and Special Studies) within the Programmatic Analysis section of this opinion.

7.5.1.9.2. Maintenance and Repair

Reclamation proposes to continue to minimize and avoid salvage disruptions by, to the extent possible, conducting most planned outages during shutdowns of Jones Pumping Plant, which typically occur in the spring and continue into the summer and fall months. For unplanned facility maintenance, Reclamation will provide notice as soon as practicable and minimize the duration of the salvage outage.

7.5.1.9.3. Exposure and Response of Listed Salmonids and sDPS Green Sturgeon During Operations

Carbon dioxide treatment is continuing to be used in the bypass or secondary channels to remove predators during the periods of the year when listed salmonids are present in salvage. Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon have the potential to be present during the carbon dioxide treatment. Any listed salmonids or sDPS green sturgeon present in the bypasses or secondary channel at the time of the predator removal will be exposed to the effects of the elevated dissolved carbon dioxide concentrations in the water of the secondary channels. However, Wu et al. (2023) reported that the currently recommended carbon dioxide concentration of 185.0 mg/L is lower than the concentration found by Cai et al. (2014) to cause mortality in Chinook salmon after 20 minutes of exposure (300.0 mg/L). Also, while larger CCV steelhead are able to hold in those areas as do other predators such as striped bass, smaller Chinook salmon are less likely to be holding in the bypasses or secondary channel so are less likely to be exposed to the high carbon dioxide conditions during a predator flush.

Reducing the predator density within the secondary channels will enhance survival through the Tracy Fish Collection Facility by reducing predation on listed salmonids and sDPS green sturgeon passing through the secondary channel to the holding tanks. Predator removal targets those predators that are present in the secondary channel and bypass system, many of which are resident or semi-resident within the system. Removal of these predators reduces the standing population of predators within the Tracy Fish Collection Facility. During a predator clean out of the secondary channel, water is directed into the holding tank used for salvage counts while the carbon dioxide is injected into the secondary channel. Predators that are anesthetized by the carbon dioxide are drawn into the holding tanks by the water flow where they can be removed from the system during regular salvage counts. Listed salmonids may be exposed to the effects of the increased dissolved carbon dioxide (hypercapnia) during predator removals and also become anesthetized. A proportion of the fish present during carbon dioxide treatment, due to their small size, may die due to the effects of the increased carbon dioxide levels in their bloodstream. However, the reduction in predation loss within the Tracy Fish Collection Facility, resulting in greater salvage efficiency and higher overall survival, will offset the number of fish lost through exposure to the elevated carbon dioxide concentrations in the secondary channels during a predator clean out.

The development of the ALPS-IP is proposed to provide more accurate loss estimates at the export facilities. The implementation of this tool is expected to improve the accuracy and reliability of fish survival estimates. Having more accurate loss estimates will help Reclamation and fisheries agencies determine current loss and better provide operational recommendations.

Juvenile Chinook salmon are exposed to the monthly ongoing louver cleaning activity. Those juveniles are lost through the louvers when they are lifted for cleaning. The current loss equation does not incorporate additional loss as a result of primary louver cleaning, and exports often continue during Tracy Fish Collection Facility outages. The ALPS-IP would be implemented and would likely provide a more accurate loss estimate. However, since the loss equation does not account for loss during louver cleaning, the calculated and reported loss of juvenile Chinook salmon are likely underestimating the actual loss of juvenile Chinook salmon.

7.5.1.10. John E. Skinner Delta Fish Protective Facility

The John E. Skinner Delta Fish Protective Facility was built in the 1960s and was designed to prevent fish from being entrained into the water flowing to the Harvey O. Banks Pumping Plant, which lifts water from the inlet canal into the California Aqueduct. The fish screening facility was designed to screen a maximum flow of 10,300 cfs. Water from the Delta is first diverted into CCF, a large artificially flooded embayment that serves as a storage reservoir for the pumps, prior to flowing through the louver screens at the Skinner Delta Fish Protective Facility. After water enters CCF through the radial gates, it first passes a floating debris boom before reaching the trash rack. The floating debris boom directs large floating material to the conveyor belt that removes the floating material for disposal in an upland area. Water and fish flow under the floating boom and through a trash rack (vertical steel grates with 2-inch spacing) before entering the primary screening bays. There are seven bays, each equipped with a flow control gate so that the volume of water flowing through the screens can be adjusted to meet hydrodynamic criteria for screening. Each bay is shaped in a “V” with louver panels aligned along both sides of the bay. The louvers are composed of steel slats that are aligned 90 degrees to the flow of water

entering the bay with 1-inch spacing between the slats. The turbulence created by the slats and water flowing through the slats guides fish to the apex of the "V" where bypass orifices are located. Fish entrained into the bypass orifice are carried through underground pipes to a secondary screening array. The older array uses the vertical louver design, while the newer array uses a perforated flat plate design. Screened fish are then passed through another set of pipes to the holding tanks. Fish may be held in the holding tanks for up to 8 hours, depending on the density of salvaged fish and the presence of listed species.

DWR will operate the facility to screen fish from the Banks Pumping Plant. Fish are salvaged in flow-through holding tanks, monitored by a 30-minute fish count every 120 minutes of exports, and transported by truck to release sites near the confluence of the Sacramento and San Joaquin rivers. Larval smelt sampling commences upon detection of a spent female at Tracy Fish Collection Facility or Skinner Delta Fish Protective Facility or when a temperature trigger of 53.6°F (12°C) at nearby CDEC stations is met. Salvage and operations data necessary to calculate loss are made available daily by 10 a.m. The standard operating procedures for the Skinner Delta Fish Protective Facility are included as Attachment "SDFPF Operations Manual_WY2023_Final" (U.S. Bureau of Reclamation 2023-2024).

At the Tracy Fish Collection Facility, the louvers are not 100-percent efficient at screening fish from the water flowing past them. Louver efficiency is assumed to be approximately 75 percent (74 percent, California Department of Water Resources 2005) for calculating the loss through the system. Louver efficiency estimates for Chinook salmon developed in the past 10 years are largely consistent with the findings of the original testing program for the Skinner Delta Fish Protective Facility (Skinner 1974). More recent studies have examined louver efficiencies at the Skinner Delta Fish Protective Facility. Clark et al. (2009) found louver efficiencies for CCV steelhead using releases of PIT-tagged hatchery CCV steelhead released at the Skinner Delta Fish Protective Facility trash rack. The study reported two estimates of efficiency: 74 percent (ranging from 17 to 100 percent) and 82 percent (ranging from 19 to 100 percent). The latter value incorporates an estimate of emigration from the study area (e.g., "swim out"), which was documented in the study. Wunderlich (2015) used fall-run Chinook salmon tagged with PIT tags, which were released in front of the Skinner Delta Fish Protective Facility in April and May of 2013. Louver efficiency was reported as 74 percent (ranging from 71 to 76 percent). Miranda (2019) utilized releases of PIT and acoustic-tagged fall and late-fall run Chinook salmon released at the Skinner Delta Fish Protective Facility trash rack. Efficiency was reported as 81.7 percent (ranging from 77.9 to 86.2 percent) and 55.0 percent (ranging from 54.3 and 55.7 percent) for "Salmon" and "Striped Bass" Operating Criteria, respectively.

"Pre-screen loss" is the estimated loss of fish between the radial gates at the entrance to the CCF to the trash rack in front of the primary louver bays at the Skinner Delta Fish Protective Facility. Gingras (1997) estimated pre-screen loss to range from 63 to 99 percent. Clark et al. (2009) calculated pre-screen loss rates from paired releases of PIT and acoustic-tagged fish released at the CCF radial gates and at the Skinner Delta Fish Protective Facility trash rack. Pre-screen loss was calculated as 82±3 percent and 78±4 percent (when adjusted for the emigration of tagged fish from CCF). Wunderlich (2015) utilized releases of PIT-tagged, fall-run Chinook salmon released at the radial gates and the Skinner Delta Fish Protective Facility in April and May of 2013. A pre-screen loss rate of 81.14 percent was reported, ranging from 41 to 100 percent. Miranda (2016) utilized PIT-tagged late-fall and fall-run Chinook salmon released at the CCF

radial gates from January through May of 2016. Monthly estimates of mean pre-screen loss ranged from 75 to 91 percent, with a season mean estimate of 91 percent. Miranda (2019) utilized releases of PIT and acoustic tagged fall and late-fall run Chinook salmon released at the CCF radial gates and at the head of the Skinner Delta Fish Protective Facility. Pre-screen loss was estimated at 77.16 percent for all races combined. Pre-screen loss was estimated as 56.07 percent (26.1 to 88.5 percent) for late fall-run Chinook salmon and 92.1 percent (92.1 to 98.5 percent) for fall-run Chinook salmon.

Losses due to cleaning the primary louvers at the Skinner Delta Fish Protective Facility are quite low compared to the Tracy Fish Collection Facility. The Skinner Delta Fish Protective Facility was built with a modular design, including multiple primary louver bays that can be isolated, two secondary channels, and two holding tank buildings. Under most circumstances, this design effectively mitigates fish losses as a result of routine maintenance, cleaning, and mechanical breakdowns. Maintenance, cleaning, and breakdowns normally result in a reduction in overall available capacity rather than exports without salvage. However, in the event of an unplanned outage (e.g., a power loss), attempts are made to immediately rectify the issue through either changes in the configuration of the facility (e.g., changing bays) or backup systems (e.g., alternate power source), and CDFW is notified. In the event of an unplanned outage lasting greater than 1 hour, CDFW is immediately consulted and/or Banks Pumping Plant exports may be temporarily halted. Planned outages are typically scheduled to avoid periods of unscreened water export. For example, major maintenance activities are scheduled in the spring during a 1-week complete shutdown of Banks Pumping Plant. During other periods, the export capacity of the facility is reduced accordingly.

The duration and frequency of louver cleaning operations fluctuate significantly due to a number of factors, including pumping schedule, high fish counts, flow rates, debris loads, environmental factors, and staffing. In general, cleaning of individual primary louver bays is performed weekly. It takes a minimum of 2 hours to clean each bay, and bays are isolated during cleaning to prevent fish losses. Cleaning is performed by lifting individual louver panels using a gantry crane and pressure washing them from both front and back.

Cleaning of the secondary channels is performed twice weekly and is also used as a predator flush. It generally takes 30 to 60 minutes to clean each secondary bay. During cleaning, each channel is dewatered, and the louver or screen panels are pressure washed from each side using a fire hose. After the panels have been washed, the primary bypass valve(s) at the head of each bay are opened rapidly to flush predators and debris into a holding tank for removal.

7.5.1.10.1. Alternative Loss Equation

DWR, in coordination with Reclamation, proposes to develop the Alternative Loss Pilot Study Implementation Plan and to implement the resulting pilot study, which would include consideration of additional salvage facility loss parameterization and procedural modifications. The goal of this pilot study is to provide a more accurate estimate of loss, and loss parameters, at the SWP and CVP export facilities while understanding the utility of the new alternative method relative to the existing method. For more details about and evaluation of the Alternative Loss Pilot Study Implementation Plan, See Section 3.11.11 in the full-text proposed action in

Appendix A and the Adaptive Management Actions and Special Studies section within the Programmatic Analysis section of this opinion.

7.5.1.10.2. Maintenance and Repair

Reclamation proposes to continue to improve salvage efficiency at the Tracy Fish Collection Facility by providing the fish agencies notification of salvage disruption (salvage outage) due to planned facility maintenance at least 24 hours in advance.

DWR proposes to continue to minimize and avoid salvage disruptions. DWR conducts most planned outages during shutdowns of Banks Pumping Plant, frequently in the spring. Many maintenance and repair activities can be conducted without disruption to salvage operations due to the modular design of the facility. For unplanned facility maintenance, DWR will provide notice as soon as practicable. For unplanned salvage operation outages beyond 1 hour, DWR will stop pumping but may continue to operate the CCF radial gates and minimize the duration of the salvage outage.

7.5.1.10.3. Exposure and Response of Listed Salmonids and sDPS Green Sturgeon During Operations

Salvage of fish occurs at the Skinner Delta Fish Protective Facility year-round, except during periodic outages or maintenance activities. Fish are salvaged in flow-through holding tanks that provide continuous flows of water. The number of fish that are salvaged in Skinner Delta Fish Protective Facility holding tanks is generally estimated by performing a 30-minute fish-count subsample every 120 minutes of pumping at Banks. However, this may change due to the number of fish salvaged or the level of debris in the holding tank. The fraction of time sampled is used to calculate the salvage expansion factor, like at the Tracy Fish Collection Facility. Because of the modular design of the Skinner facility, salvage operations outages are quite uncommon since most repair and maintenance actions do not require pausing salvage operations. Fish are usually transported to DWR-owned release sites on Sherman Island—one on the San Joaquin River side near Curtis Landing and three on the Sacramento River side. With the permission of Reclamation, fish may also be released at the two currently operational Reclamation-owned release sites near Antioch and Emmaton.

The effects of collection, handling, trucking, and release operations have been evaluated in a number of studies at the Skinner Delta Fish Protective Facility, as outlined below. Raquel (1989) found that survival rates for Chinook salmon were never less than 98 percent and, in most cases, were 100 percent. The loss equation used by CDFW to calculate SWP losses utilizes the 2 percent value. This study also found no detrimental effects to CCV steelhead from the handling and trucking process. Miranda and Padilla (2010) found that the survival of Chinook salmon exposed to a mock salvage release process was 99.2 percent, 97.4 percent, and 98.4 percent in trials with no debris, moderate debris, and heavy debris, respectively. There was no significantly detectable effect on survival from the release process. In a more recent study evaluating other release parameters, Hammen et al. (2021) reported that altering the frequency from a salvage release every day (perhaps more predictable to local predatory fish) to a salvage release every fifth day did not reduce relative predation rates but did find that relative predation rates were lower during dawn and dusk and with deeper water releases.

7.5.1.11. Tidal Habitat Restoration

This proposed action component is described in the Programmatic Analysis section of this opinion.

7.5.1.12. Delta Smelt Supplementation

This proposed action component is an Adaptive Management Action described in the Programmatic Analysis section of this opinion.

7.5.1.13. Water Transfers

Reclamation and DWR propose to operate the CVP and SWP to facilitate transfers through providing water in streams for delivery to alternative diversion points, conveying water across the Delta for export, or storing water for delivery at a future time.

Seasonal operations describe deliveries up to contract totals. Included in this consultation is transfers of water, up to contract totals, between CVP contractors within counties, watersheds, or other areas of origin (e.g., Accelerated Water Transfers). These transfers do not require demonstration of that water being consumptively used or irretrievably lost to beneficial use.

Transfers not meeting these requirements, including Out of Basin transfers (e.g., Long Term Water Transfer Program (North to South-of-Delta Transfers, Long Term San Joaquin River Exchange Contractor Transfers, "Warren Act Transfers"), follow the Draft Technical Information for Preparing Water Transfer Proposals, as updated in 2019 (Water Transfers White Paper). The actions taken by contractors to make water available for these transfers (i.e., reducing consumptive use by crop idling, contractor reservoir releases or groundwater substitution) have separate ESA section 7 consultation (see Programs in the Environmental Baseline for additional information), and are not part of this consultation. However, the specific timing and operations associated with the movement of the water to be transferred is a component of this Proposed Action and, thus, covered by this consultation. Maximum North to South water transfers would be limited to the volumes provided in BA Table 3.14 (U.S. Bureau of Reclamation 2023-2024) and would occur from July 1 through November 30. Real-time operations may restrict transfers within the transfer window so that Reclamation and DWR can meet other authorized project purposes, e.g., when pumping capacity is needed for CVP or SWP water. The proposed water transfers component requires that NMFS make the following assumptions:

- Development of the water supplies for water transfers will be conducted in a manner that includes the necessary consultation process with NMFS for impacts to listed species, as applicable; and
- Any upstream impacts to listed species associated with the operation of non-CVP and SWP facilities for transfer through the South Delta export facilities will be the subject of their own consultation process.

Water transfers would be subject to all measures applicable for the Delta, including Seasonal Operations (Section 3.7.1 of the BA [U.S. Bureau of Reclamation 2023-2024]) and OMR Flow Management (Section 3.7.4 of the BA [U.S. Bureau of Reclamation 2023-2024]). The contribution of transfer water to South Delta export levels can affect hydrodynamic conditions in the South Delta, such as OMR, but it is not possible to isolate the specific effects of the transfer water in most lines of evidence presented in the BA. The effects of water transfers are included

in the overall Delta hydrodynamic conditions and biological modeling outcomes discussed in Section 7.5.1.3 (Delta Effects Lines of Evidence) and are covered under the analysis for OMR Management (Section 7.5.1.6) and Spring Delta Outflow (Section 7.5.1.7). NMFS relies on the effects to species described in those sections to capture the impacts of export operations under the proposed action, and no further species-specific effects analysis is provided here.

7.5.1.14. Agricultural Barriers

DWR proposes to construct and operate three agricultural barriers in the channels of the South Delta each year, and Reclamation proposes the ongoing operation of the agricultural barriers as part of the proposed action. On March 23, 2023, NMFS issued a separate biological opinion to the USACE for the construction effects of these barriers and their operations through operational season 2027.

DWR constructs the three barriers in the South Delta each spring to provide water surface elevation protection for South Delta agricultural diverters. These barriers are constructed on Old River near Tracy, 0.5 miles upstream of the Tracy Fish Collection Facility, on Middle River 0.5 miles upstream of the junction with Victoria Canal, and on Grant Line Canal about 400 feet upstream of the Tracy Boulevard Bridge. The barriers are constructed using large boulders and cobble and have multiple steel culverts to allow the flow of water through each barrier. The culverts have tidally-operated flap gates which allow the culverts to be completely closed on the ebb tide to trap water behind the barrier and open on the flood tide to allow water to flow upstream. The center of each barrier is lower than the abutments on each bank and acts as a weir that allows flood tides to overtop it and pass tidal flow upstream. On the ebb tide, water can flow downstream over the weir crest until the upstream water elevation reaches the elevation of the weir crest, at which point the barrier behaves as a low-head dam with only minimal river flow passing over it.

The proposed action explains that DWR may install the agricultural barriers as early as May 1 each year. Appendix G (Specific Facility and Water Operations Deconstruction in U.S. Bureau of Reclamation 2023-2024) mentions that installation may occur "between April and July." NMFS has analyzed effects assuming, as described in the proposed action, that construction will not begin before May 1. Closure of the barriers is typically completed by May 15, and the tidal flap gates are tied open. From May 15 to May 31, the tidal flap gates may be untied and become fully functional if DWR clearly demonstrates that water surface elevations in the South Delta are sufficiently low to impact South Delta irrigators from diverting water. By June 1 each year, the barriers can become fully functional, and the flap gates left untied. The Grant Line Canal barrier may still be left with the flap gates tied open and the center section of the barrier removed at the request of CDFW, USFWS, or NMFS if there are Delta smelt incidental take concerns. Finally, at least one culvert at each barrier will be kept open to allow for fish passage when water temperatures are less than 22°C, even if the previous conditions have been met.

As described in the programmatic BA for the construction of the south Delta agricultural barriers, starting on September 15 each year, the agricultural barriers at Middle River and Old River at Tracy must be notched to allow for the passage of adult fall-run Chinook salmon and the appropriate number of flashboards must be removed at the Grant Line barrier to provide for passage of adult fall-run Chinook salmon. By November 30 each year, all barriers must be removed from their respective waterways (ICF ESA Joint Venture 2022).

Temporary agricultural barriers, constructed in the spring to provide water surface elevation protection for Delta agricultural diverters, can cause delays to migration or result in the isolation of fish, preventing them from reaching suitable habitats. DWR issued a report regarding the effects of the South Delta agricultural barriers on the survival of emigrating juvenile salmonids, including both Chinook salmon and steelhead (California Department of Water Resources 2018b). This study showed that by delaying migration and increasing the time that juvenile salmonids spent in the vicinity of the barriers, the fish were increasingly exposed to elevated water temperatures as the season progressed. This could, in turn, diminish the physiological state of the fish, making them more vulnerable to predation.

Reclamation provided limited information in their BA and supporting documents to assess the impacts of the construction of the three agricultural barriers in the South Delta on listed salmonids and sDPS green sturgeon. Based on previous consultations for the construction of the agricultural barriers with the USACE, the construction of the barriers will create adverse water quality conditions (turbidity and suspended sediment) as well as create disturbances within the three channels of the South Delta where the barriers are located that will negatively affect listed fish present in the waterways during construction. In contrast, sufficient information regarding the impacts of the operations of the South Delta barriers on listed salmonid migration behavior and increased vulnerability to predation was presented (California Department of Water Resources 2018b) to assess the impacts of the operations of the South Delta barriers under this proposed action component. Therefore, construction of the barriers will be treated programmatically and additional consultation will occur when DWR seeks to renew their permits with state and federal agencies for the South Delta barriers. Operations of the barriers after construction will be covered by this consultation.

7.5.1.14.1. Assess Species Exposure to Proposed South Delta Agricultural Barrier Operations

7.5.1.14.1.1. Sacramento River Winter-Run Chinook Salmon

Adult SR winter-run Chinook salmon do not spawn in the San Joaquin River basin and, therefore, are unlikely to enter the waterways of the South Delta or encounter the barriers during their migration. Juvenile SR winter-run Chinook salmon have the potential to be in the locations of the South Delta agricultural barriers due to their observed presence in the salvage of the Tracy Fish Collection Facility and the Skinner Delta Fish Protective Facility from January through April. The Middle River and Old River at Tracy barriers are only 0.5 miles away from waterways known to contain juvenile SR winter-run Chinook salmon (Old River adjacent to the Tracy Fish Collection Facility, and Victoria Canal at the junction with Middle River). Because construction of the barriers does not start until May 1 each year, it is unlikely that any juvenile SR winter-run Chinook salmon will be present in the waters of the South Delta during the construction and operations of the agricultural barriers.

7.5.1.14.1.2. Central Valley Spring-Run Chinook Salmon

Based on historical salvage data, prior to the efforts to re-establish CV spring-run Chinook salmon into the San Joaquin River basin, juvenile CV spring-run Chinook salmon were present at the fish salvage facilities from February through June. Since the agricultural barriers on Middle River and on Old River at Tracy are located within close proximity to waterways known

to contain CV spring-run Chinook salmon, the presence of juvenile CV spring-run Chinook salmon during the construction and operations of the barriers is assumed. The presence of juvenile CV spring-run Chinook salmon from the Sacramento River basin at the Grant Line barrier is also possible, given the effects of tides in these waterways, which can push juvenile salmon upstream to the location of that barrier.

7.5.1.14.1.3. California Central Valley Steelhead

Both adult and juvenile CCV steelhead will be present at the locations of the agricultural barriers during construction and operations. Adult CCV steelhead will encounter the barriers during their upstream migrations in the fall when the barriers are still in place prior to their removal by the end of November each year. Adult CCV steelhead migration into the San Joaquin River basin starts in approximately September and continues through early winter (December and January). Juvenile CCV steelhead emigration from the San Joaquin River basin can start in winter but peaks in April and May, which overlaps with the construction and early operations of the barriers. It is also possible to have Sacramento River basin CCV steelhead in the vicinity of the barriers in April and May based on the salvage records from the CVP and SWP fish salvage facilities.

7.5.1.14.1.4. Southern Distinct Population Segment of Green Sturgeon

Both juvenile and adult sDPS green sturgeon are assumed to be present in the waters of the South Delta adjacent to the location of the agricultural barriers. Based on salvage records from the CVP and SWP fish salvage facilities and sturgeon fishing report cards (California Department of Fish and Wildlife 2021), observations of sDPS green sturgeon have occurred year-round in this region.

7.5.1.14.2. Assess Response to Proposed South Delta Agricultural Barrier Operations

7.5.1.14.2.1. Listed Salmonids

The California Department of Water Resources (2018b) stated that the presence of the South Delta agricultural barriers will considerably reduce juvenile salmonid survival compared to open channels. Survival is lowest when the barriers are installed and the flap gates are closed. Survival improved when the flap gates were tied open. Survival was also reduced during the construction of the barriers. Juvenile salmonids were typically preyed upon upstream of the barriers, while delayed on their downstream migration. Predator density increased after the construction of the barriers but most noticeably upstream of the barriers. The barriers increased the time that juvenile salmonids spent in the vicinity of the barriers, which likely increased their vulnerability to predators located upstream of the barriers. Juvenile salmonids encountering the barriers will move downstream through open culverts preferentially, but few fish were detected moving over the weir crest if the culverts were tied open. If the culverts were tidally operated, fish could only go through when the flood tide pushed them open. Under these conditions, more juvenile salmonids went over the weir crest but could only do so when flows overtopped the weir crest on flood tides or on ebb tides before the water elevations declined to the point where water depth was diminished over the crest. By increasing the time that juvenile salmonids spent in the vicinity of the barriers, the fish were also vulnerable to being exposed to elevated water

temperatures as the season progressed. This could diminish the physiological state of the fish, making them more vulnerable to predation.

Adult CCV steelhead migrating into the San Joaquin River watershed are most likely to encounter the barriers with the notches in place (i.e., after September 15). However, passage is likely only possible during the flood tides or on the falling ebb tide immediately after slack when there is still adequate water depth to facilitate passage.

The proposed agricultural barriers will lead to lower survival of CCV steelhead juveniles emigrating from the San Joaquin River basin by up to 20 percent for flows between 3,800 cfs and 5,000 cfs at Vernalis. This information parallels the information provided in California Department of Water Resources (2018b), which indicated reduced survival through the South Delta routes when the agricultural barriers are being constructed and when they are in place. During years in which spring-time Vernalis flows do not exceed 5,000 cfs, Reclamation's proposed agricultural barriers create conditions that would reduce CCV steelhead survival to Chipps Island for the Southern Sierra Nevada Diversity Group.

7.5.1.14.2.2. Southern Distinct Population Segment of Green Sturgeon

There is an absence of information regarding sDPS green sturgeon behavior around the South Delta barriers. Like salmonids, the barriers present a migration blockage for fish moving either upstream or downstream when the barriers are in place. It is unlikely that any sDPS green sturgeon, either an adult or juvenile, will pass over the top of the weir crest, even during flood tides. Southern DPS green sturgeon may pass through the culverts, but it is unknown whether they will volitionally do this. Fish that are upstream of the barriers after the culverts begin to be tidally operated are likely to be trapped upstream of the barrier. Under these conditions, the only route back to the main Delta waterways may be to return to the mainstem San Joaquin River to regain access to the Delta.

7.5.1.14.3. Summary of Effects of Proposed South Delta Agricultural Barrier Operations

7.5.1.14.3.1. Listed Salmonids

Juvenile CV spring-run Chinook salmon, as well as both juvenile and adult CCV steelhead, are expected to encounter the barriers while they are present in the channels of Old River, Middle River, and Grant Line Canal. The barriers will present a substantial impediment to migration both as a physical structure and as a source of mortality to individuals through increased predation (DWR 2018). Delays in migration can also expose fish to elevated water temperatures, combined with increasingly hypoxic conditions as the season progresses, making any prolonged delay potentially lethal due to the thermal tolerances of the fish and increased vulnerability to predation.

7.5.1.14.3.2. Southern Distinct Population Segment of Green Sturgeon

Both juvenile and adult sDPS green sturgeon will encounter the barriers when they are present in Old River, Middle River, and Grant Line Canal. The barriers will present a physical barrier to movements within the Delta for both juveniles and adults. The barriers are equipped with culverts to allow fish passage, but anecdotal evidence indicates that sturgeon are reluctant or hesitant to enter covered structures such as tunnels or culverts. As a result, the culverts will not

likely provide sDPS green sturgeon passage, even when the flap gates are tied open. Although the barriers would impede sDPS green sturgeon migration within the interior channels of the Delta, juveniles typically rear in the Delta for multiple years, and therefore, blocked migration is not expected to greatly decrease individual fitness or survival. There is currently insufficient evidence to determine the extent to which predation on juvenile sDPS green sturgeon occurs within the Delta, or whether the operation of the barriers will exacerbate predation, diminish the physiological condition of individual fish, or otherwise affect the quality and ability of the habitat to provide the ecological functions on which the species depends (i.e., rearing and migration).

Table 137 summarizes the individual species analysis of exposure and response associated with the consequences of the component of the proposed action element for operation of South Delta Agricultural Barriers.

Table 137. Information used to identify effects of the proposed action from South Delta Agricultural Barrier Operations on species.

Proposed Action element	Species	Stressors	Life Stage (Location)	Life Stage Timing (Work Window Intersection)	Individual Response and Rationale of Effect	Severity of Stressor	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence
South Delta Agricultural Barrier Operations	Central Valley spring-run Chinook salmon	Straying or delayed migration	Adult (San Joaquin Origin)	Jan. - June (May 15. - June)	Altered or delayed migration; increase to straying; reduced spawning success	Minor to Sublethal	Medium (17% to 25%)	High - Annual construction and operation of South Delta barriers	Medium	Medium - conceptual understanding of adult migration despite limited monitoring, models to support understanding of Delta hydrodynamics.
South Delta Agricultural Barrier Operations	Central Valley spring-run Chinook salmon	Flow (routing), and predation	Juvenile (San Joaquin Origin)	Young-of-year: Dec. - June (May 15. - June) Yearling: Nov. - Feb. (Nov.)	Altered or delayed migration; increased risk to predation; reduced migration success, increased risk of mortality	Sublethal to Lethal	Medium (Young-of-year: 17% to 25%; Yearling: <25%)	High - Annual construction and operation of South Delta barriers	High	High - Multiple studies/publications regarding juvenile survival in various Delta migratory routes; conclusions supported by modeling results.
South Delta Agricultural Barrier Operations	California Central Valley steelhead	Straying or delayed migration	Adult (San Joaquin Origin)	Aug. - May. (Aug. - Nov)	Altered or delayed migration; increase to straying; reduced spawning success	Minor to Sublethal	Medium (<40%)	High - Annual construction and operation of South Delta barriers	Medium	Medium - conceptual understanding of adult migration despite limited monitoring, models to support understanding of Delta hydrodynamics.
South Delta Agricultural Barrier Operations	California Central Valley steelhead	Flow (routing), and predation	Juvenile (San Joaquin Origin)	Dec. - July (May 15. - July)	Altered or delayed migration; increase risk to predation; reduced migration success, increased risk of mortality	Sublethal to Lethal	Medium (<31%)	High - Annual construction and operation of South Delta barriers	High	High - Multiple studies/publications regarding juvenile survival in various Delta migratory routes; conclusions supported by modeling results.

Proposed Action element	Species	Stressors	Life Stage (Location)	Life Stage Timing (Work Window Intersection)	Individual Response and Rationale of Effect	Severity of Stressor	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence
South Delta Agricultural Barrier Operations	sDPS green sturgeon	Delayed migration	Adult (S. Delta)	Jan. - Dec. (May 15 - Nov.)	Altered migration; Entrainment; reduced spawning success	Minor to Sublethal	Medium (<54%)	High - Annual construction and operation of South Delta barriers	Medium	Low - Limited understanding and monitoring of Delta movement, models to support understanding of Delta hydrodynamics.
South Delta Agricultural Barrier Operations	sDPS green sturgeon	Flow (routing), and predation	Juvenile/sub-adult (S. Delta)	Jan. - Dec. (May 15 - Nov.)	Altered migration, Entrainment; reduced growth	Minor to Sublethal	Medium (<54%)	High - Annual construction and operation of South Delta barriers	Medium	Low -Limited understanding and monitoring of Delta movement, models to support understanding of Delta hydrodynamics.

7.5.1.15. Barker Slough Pumping Plant

7.5.1.15.1. Physical Description of the Barker Slough North Bay Aqueduct Infrastructure

The North Bay Aqueduct is part of the SWP. The Barker Slough Pumping Plant diverts water from Barker Slough into the North Bay Aqueduct for delivery to the Solano County Water Agency and the Napa County Flood Control and Water Conservation District (North Bay Aqueduct entitlement holders). The North Bay Aqueduct is an underground pipeline that runs from Barker Slough in the northern Delta to Cordelia Forebay, just outside of Vallejo. From Cordelia Forebay, water is pumped to Napa County, Vallejo, and Benicia. The North Bay Aqueduct also serves Travis Air Force Base. The size of the pipeline varies from a diameter of 72 inches at Barker Slough to 54 inches at Cordelia Forebay. Maximum pumping design capacity is 175 cubic feet per second (pipeline capacity). During the past few years, daily pumping rates have ranged between 0 and 140 cfs. The current maximum pumping rate, as determined through testing of the existing pumps, is 142 cfs. The difference between the design maximum and the tested maximum is due to the physical limitations of the existing pumps. The growth of biofilm in a portion of the pipeline also limits the North Bay Aqueduct's ability to reach its full pumping capacity.

The North Bay Aqueduct intake is located approximately 10 miles from the mainstem Sacramento River at the end of Barker Slough. Each of the 10 North Bay Aqueduct pump bays is individually screened with a positive barrier fish screen consisting of a series of flat, stainless steel, wedge-wire panels with a slot width of 3/32 inch that meets NMFS fish screening criteria (National Marine Fisheries Service 2022e). This configuration is designed to exclude fish approximately 1 inch or larger from being entrained. The inlet bays tied to the two smaller pumping units have an approach velocity of about 0.2 feet per second. The larger units were designed for a 0.5 feet per second approach velocity, but the actual approach velocity is about 0.44 feet per second. The screens are cleaned monthly to prevent excessive head loss, thereby minimizing increased localized approach velocities ("hotspots" on the screen).

Water Diversion

DWR, at its sole expense, will operate the Barker Slough Pumping Plant to an annual maximum diversion of 125 TAF and a maximum daily diversion rate of 175 cfs. Cumulative Barker Slough Pumping Plant diversions for the January 1 to March 31 period, at design capacity, are limited to approximately 26 TAF. From January 1 to March 31 of dry and critical water years, DWR proposes to operate to a maximum seven-day average diversion rate at Barker Slough Pumping Plant less than 100 cfs. Cumulative Barker Slough Pumping Plant diversions for the March to June period, at design capacity, is 42 TAF. DWR, at its sole expense, from March 1 to April 30 of dry and critical water years, if catch of larval Delta smelt (length less than 25mm) in 20mm survey at station 718 exceeds 14 percent of the total catch of larval Delta smelt across the North Delta (20mm survey stations 716, 718, 719, 720, 723, 724, and 726), then DWR proposes to operate to a maximum seven-day average diversion rate at Barker Slough Pumping Plant less than 60 cfs.

DWR, at its sole expense, from May 1 to June 30 of dry and critical water years, if catch of larval Delta smelt (length less than 25mm) in 20mm survey at station 716 exceeds 5 percent of

the total catch of larval Delta smelt across the North Delta (20mm survey stations 716, 718, 719, 720, 723, 724, and 726), then DWR proposes to operate to a maximum seven-day average diversion rate at Barker Slough Pumping Plant less than 100 cfs.

Pumping is typically lower in the winter and early spring (December through April) than in the summer and fall (May through November), as shown in Table 138 and Table 139.

Table 138. Monthly diverted volumes in acre-feet from the Barker Slough Pumping Plant for the water years 2008 to 2018.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2008	2,491	1,395	937	4,142	5,739	7,023	7,068	7,039	6,355	5,776	4,797	2,915
2009	3,235	1,909	95	1,390	5504	5560	5264	5140	4368	3914	4305	1611
2010	921	1,172	539	1,467	4369	5856	6555	6434	6104	5131	4204	1382
2011	323	742	239	580	3426	4674	6151	6029	6255	4532	4315	3064
2012	2,430	306	332	412	2033	5311	5792	5592	6490	5225	4607	1501
2013	952	1,137	659	2,314	6275	6573	6322	6452	5588	5932	3871	3468
2014	3,728	1,165	1,133	3,579	6615	4789	3928	4095	2568	3006	1218	833
2015	1,121	1,544	1,629	3,358	3561	3377	3313	4447	4186	4196	3285	1167
2016	977	948	19	519	3083	4735	5385	4753	4180	3670	2847	2050
2017	1,014	944	222	411	2944	3265	3357	5895	5789	5513	4695	4182
2018	2,735	3,502	1,562	325	4,665	6,013	5,971	5,975	5,589	5,011	5,312	3,431

Table 139. Average monthly diverted flows in cubic feet per second from the Barker Slough Pumping Plant for the water years 2008 to 2018.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2008	40.5	25.1	15.2	69.6	93.3	118.0	114.9	114.5	106.8	93.9	80.6	47.4
2009	52.6	34.4	1.5	23.4	89.5	93.4	85.6	83.6	73.4	63.7	72.3	26.2
2010	15.0	21.1	8.8	24.7	71.1	98.4	106.6	104.6	102.6	83.4	70.7	22.5
2011	5.3	13.4	3.9	9.8	55.7	78.5	100.0	98.1	105.1	73.7	72.5	49.8
2012	39.5	5.5	5.4	6.9	33.1	89.3	94.2	90.9	109.1	85.0	77.4	24.4
2013	15.5	20.5	10.7	38.9	102.1	110.5	102.8	104.9	93.9	96.5	65.1	56.4
2014	60.6	21.0	18.4	60.1	107.6	80.5	63.9	66.6	43.2	48.9	20.5	13.6
2015	18.2	27.8	26.5	56.4	57.9	56.8	53.9	72.3	70.3	68.2	55.2	19.0
2016	15.9	17.1	0.3	8.7	50.1	79.6	87.6	77.3	70.2	59.7	47.8	33.3
2017	16.5	17.0	3.6	6.9	47.9	54.9	54.6	95.9	97.3	89.7	78.9	68.0
2018	44.5	63.1	25.4	5.5	75.9	101.1	97.1	97.2	93.9	81.5	89.3	55.8
Mean	29.5	24.2	10.9	28.3	71.3	87.4	87.4	91.4	87.8	76.7	66.4	37.9
Median	18.2	21.0	8.8	23.4	71.1	89.3	94.2	95.9	93.9	81.5	72.3	33.3
Minimum	5.3	5.5	0.3	5.5	33.1	54.9	53.9	66.6	43.2	48.9	20.5	13.6
Maximum	60.6	63.1	26.5	69.6	107.6	118.0	114.9	114.5	109.1	96.5	89.3	68.0

The Barker Slough Pumping Plant facility is equipped with a positive barrier fish screen designed and constructed to meet NMFS fish screening criteria (National Marine Fisheries Service 2022e), and DWR intends to maintain its function and compliance with the CDFW and NMFS fish screen criteria under the proposed action component. The Barker Slough Pumping Plant facility entrains water from Barker Slough and surrounding bodies of water, including Campbell Lake, Calhoun Cut, and Lindsey Slough. It is approximately 10 miles upstream of the confluence of Lindsey Slough with Cache Slough. Due to the entrainment of water from the surrounding sloughs, the intake has the potential to entrain migrating salmonids and sDPS green sturgeon that may be present in the Cache Slough complex of channels, which includes waters discharging from the Yolo Bypass and Miners Slough.

NMFS makes the following assumptions regarding the operations of the Barker Slough Pumping Plant and North Bay Aqueduct under the proposed action (U.S. Bureau of Reclamation 2023-2024) component:

- proposed operations will not change appreciably from historical operations at the facilities;
- future export flows and volumes will remain consistent with historical operations; and
- seasonal patterns of exports will remain consistent with historical patterns.

Sediment Removal

Sediment accumulates in the concrete apron sediment trap in front of the Barker Slough Pumping Plant fish screens and within the pump wells behind the fish screens. DWR proposes to continue sediment removal from the sediment trap and the pump wells as needed (North Bay Aqueduct Sediment and Aquatic Weed Removal Operating Procedures_03.28.23 in U.S. Bureau of Reclamation 2023-2024).

Aquatic Weed Removal

DWR proposes to remove aquatic weeds, as needed, from in front of the fish screens at Barker Slough Pumping Plant. Aquatic weeds accumulate on the fish screens, blocking water flow and causing water levels to drop behind the screens in the pump wells. The low water level inside of the pump wells causes the pumps to automatically shut off to protect the pumps from cavitation. The aquatic weed removal system consists of grappling hooks attached by chains to an aluminum frame. A boom truck, staged on the platform in front of the Barker Slough Pumping Plant pumps, will lower the grappling system into the water to retrieve the accumulated aquatic vegetation. The removed aquatic weeds will be transported to spoil sites located near the pumping plant.

7.5.1.15.2. Assess Species Exposure to the Proposed Barker Slough Pumping Plant/ North Bay Aqueduct Operations

Listed salmonids may be present in the waterways adjacent to the Barker Slough Pumping Plant, however, several years of monitoring have not consistently captured any salmonids during the winter Delta smelt surveys (1996–2004) in Lindsey Slough or Barker Slough (California

Department of Fish and Wildlife 2024d). Captures of juvenile Chinook salmon have occurred in the months of February and March and typically are only a single fish per net haul. Most juvenile Chinook salmon captured came from Miners Slough, which is a direct tributary to the Sacramento River via Steamboat and Sutter sloughs. However, one fish was captured at site 721 in Barker Slough near the location of the Barker Slough Pumping Plant (Table 140 and Figure 153). No CCV steelhead or sDPS green sturgeon have been captured in the monitoring surveys from 1996 to 2004. Southern DPS green sturgeon are assumed to occur in the waters of Cache Slough and the Sacramento Deep Water Ship Channel, as they have been caught in these waters by sport anglers.

Table 140. Catches of Chinook salmon in the North Bay Aqueduct larval fish survey from 1996 to 2004.

Date	Number Caught	Site Location
2/27/2004	1	724
2/28/2001	2	724, 726
3/8/2001	1	724
2/15/2000	5	723(1), 724 (3), 726 (1)
3/18/1999	1	718
3/7/1998	1	721
2/23/1997	1	726

Source: (California Department of Fish and Wildlife 2024d).

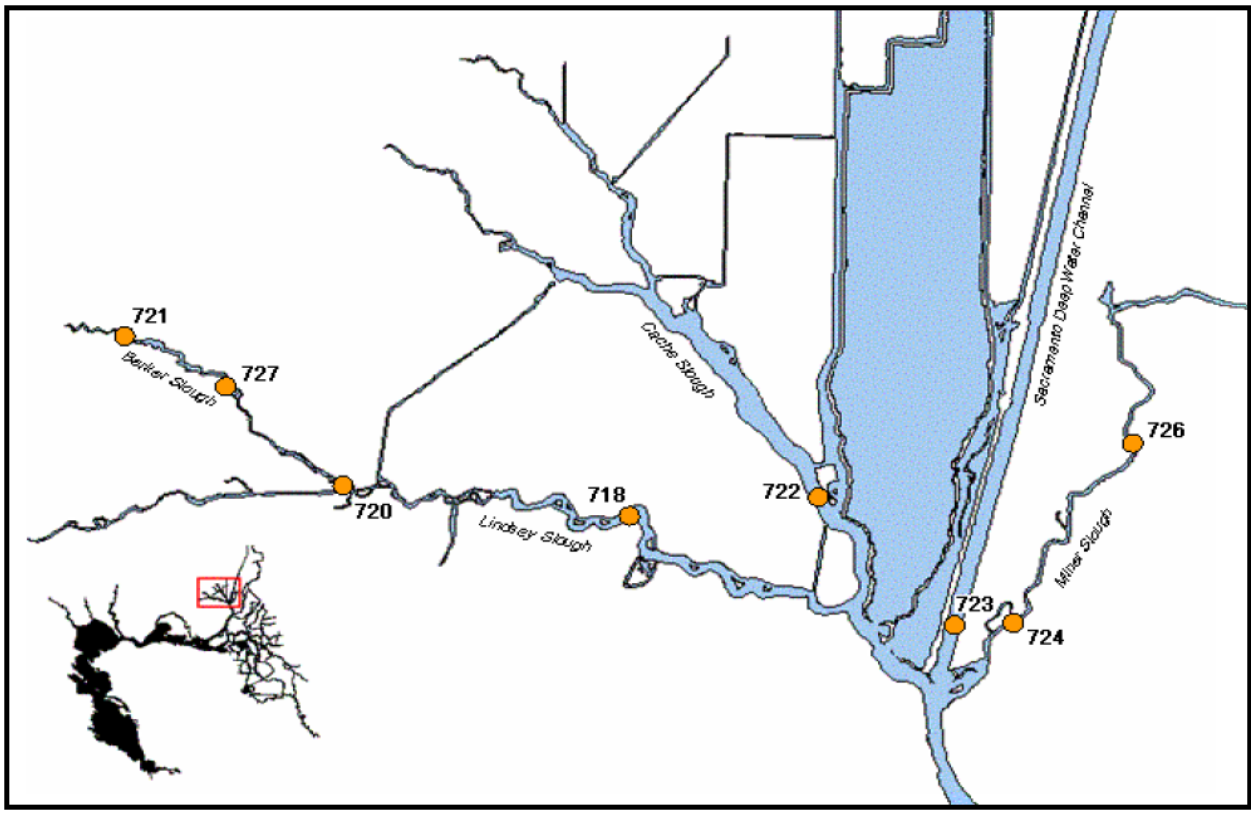


Figure 153. Map of North Bay Aqueduct larval fish survey sampling sites.

Adult salmonids are assumed to be at low risk of impingement on the fish screens, and due to the lack of inflow to the channel, are unlikely to be attracted upstream to the vicinity of the Barker Slough Pumping Plant location during their spawning migrations. Adult sDPS green sturgeon may use the waters of the Cache Slough complex opportunistically while holding in the Delta, but like adult salmonids, they are unlikely to be affected by the screens.

7.5.1.15.3. Assess Species Response to the Proposed Barker Slough Pumping Plant/North Bay Aqueduct Operations

During the winter period, exports from the Barker Slough Pumping Plant are expected to remain low, ranging from a monthly average of 10.9 cfs in March to 29.5 cfs in January based on historical patterns (California Department of Water Resources 2024b). From May to November, the average diversion flow ranges from a monthly average of 66.4 cfs in November to 91.4 cfs in August for the same 10-year period (Table 139). Monitoring by CDFW for the North Bay Aqueduct larval fish survey indicates that some Chinook salmon have been observed at the most western monitoring location (site 721) in Barker Slough, but in general, observations of Chinook salmon are rare, and occur farther to the east near the confluence of Miners Slough with the Cache Slough complex. The low diversion rate during the period from December to April is unlikely to entrain fish from the lower reaches of the Cache Slough complex to locations adjacent to the Barker Slough Pumping Plant. Even in May, the average monthly diversion rate is only about 71 cfs, with a range of 33 to 108 cfs. Even at the current maximum diversion rate of

140 cfs, the size of the channels in the Cache Slough complex would mute any flow towards the Barker Slough Pumping Plant from the lower reaches of the Cache Slough complex.

The fish screens, which were designed to protect juvenile Delta smelt and meet the NMFS criteria for salmonids, should prevent entrainment and greatly minimize any impingement of fish against the screen itself. Furthermore, the location of the pumping plant on Barker Slough is substantially removed from the expected migration corridors utilized by emigrating Chinook salmon and steelhead juveniles in the North Delta system. Southern DPS green sturgeon may be present in the waters of Lindsey and Barker sloughs since they are present in Cache Slough and the Sacramento Deep Water Ship Channel. Southern DPS green sturgeon are expected to be fully excluded by the positive barrier fish screen in place at the pumping facility.

Cleaning of the sediment that has accumulated in front of the fish screens may increase the risk of fish entrainment, depending on the method used. DWR did not describe the methodology to be used, but NMFS can make reasonable assumptions regarding this procedure. Using water jets to resuspend the sediments in front of the fish screens and then drawing this water through the screens will avoid any adverse impacts related to entrainment. In contrast, if a suction vacuum or hydraulic dredge is used to remove the sediment in front of the screens, then fish may be entrained into the suction hose or dredge head and deposited along with the sediment in the dredge spoils placement area. Removal of sediment behind the fish screens will not impact fish as the water is already screened, and no listed fish should be present within the pump wells. If cleaning takes place at a time when listed salmonids are unlikely to be present (i.e., summer with high ambient water temperatures), then the risk of exposure is greatly reduced or nonexistent.

Cleaning of the fish screen by removal of aquatic weeds and vegetation may harm fish if the grappling hooks or frame directly strike the fish or if fish become entangled in the vegetation as it is being removed and are subsequently deposited in the aggregate base spoil sites, which would be fatal. As previously stated, if vegetation removal occurs at times when listed salmonids are unlikely to be present, then the risk of negative effects is greatly reduced due to avoiding any temporal overlap between the listed species and the weed removal action. This is the likely scenario, since aquatic weeds grow fastest during the warmer seasons, and elevated exports at the Barker Slough Pumping Plant would draw the weeds into the fish screens during the summer and fall seasons when water diversions are greatest. At this time of year, it is unlikely that listed salmonids would be present in these shallow waterways.

7.5.1.15.4. Summary of the Effects of the Proposed Barker Slough Pumping Plant/North Bay Aqueduct Operations to Listed Salmonid Individuals

The presence of listed salmonids (SR winter-run Chinook salmon, CV spring-run Chinook salmon, and CCV steelhead) in the waters of Barker Slough appears unlikely based on the monitoring data available. If the fish are unlikely to be present in the vicinity of the North Bay Aqueduct export pumps based on the single observation at site 721, then there is minimal likelihood of an increase in the encounter rates with the screens due to the diversion of water. Therefore, a minimal adverse effect from the North Bay Aqueduct intake on juvenile SR winter-run Chinook salmon, CV spring-run Chinook salmon, and CCV steelhead from the Sacramento River basin is expected. Furthermore, the fish screens are designed to avoid any entrainment or impingement of Delta smelt and salmonids. Therefore, it is unlikely that any fish will be

adversely impacted by being in close proximity to the screens during water diversions. In regards to sediment removal and aquatic weed removal, the likelihood of listed salmonids being present near the Barker Slough Pumping Plant fish screens when these actions are being carried out is very low, particularly if these actions occur during the summer season when water temperatures are elevated.

7.5.1.15.5. Summary of the Effects of the Proposed Barker Slough Pumping Plant/North Bay Aqueduct Operations to Listed Southern Distinct Population Segment of Green Sturgeon Individuals

For the same reasons described for the listed salmonids above, the potential for adverse effects to sDPS green sturgeon is low. The fish screen is designed to protect Delta smelt and salmonids and will provide the same protection to juvenile sDPS green sturgeon. Southern DPS green sturgeon are unlikely to be affected by the cleaning of sediment or aquatic weeds.

Table 141 summarizes the individual species analysis of exposure and response associated with the consequences of the proposed action element of operation of Barker Slough Pumping Plant/North Bay Aqueduct Operations.

Table 141. Information used to identify effects of the proposed action from Barker Slough Pumping Plant/North Bay Aqueduct Operations on species.

Proposed Action element	Species	Stressors	Life Stage (Location)	Life Stage Timing (Work Window Intersection)	Individual Response and Rationale of Effect	Severity of Stressor	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence
Barker Slough Pumping Plant/North Bay Aqueduct Operations	Sacramento River winter-run Chinook salmon	Entrainment, and predation	Juvenile (Sac. Origin)	October - April	Altered migration; increased risk to predation, entrainment; reduced migration success, increased risk of mortality	Sublethal to Lethal	Very Small (<2%)	High - Annual operation of Barker Slough Pumping Plant and N. Bay Aqueduct	Medium	Medium - Conceptual understanding supported by monitoring and screening criteria
Barker Slough Pumping Plant/North Bay Aqueduct Operations	Central Valley spring-run Chinook salmon	Entrainment, and predation	Juvenile (Sac. Origin)	December - May	Altered migration; increased risk to predation, entrainment; reduced migration success, increased risk of mortality	Sublethal to Lethal	Very Small (<2%)	High - Annual operation of Barker Slough Pumping Plant and N. Bay Aqueduct	Medium	Medium - Conceptual understanding supported by monitoring and screening criteria
Barker Slough Pumping Plant/North Bay Aqueduct Operations	California Central Valley steelhead	Entrainment, and predation	Juvenile (Sac. Origin)	December - July and September	Altered migration; increased risk to predation, entrainment; reduced migration success, increased risk of mortality	Sublethal to Lethal	Very Small (<2%)	High - Annual operation of Barker Slough Pumping Plant and N. Bay Aqueduct	Medium	Low - Conceptual understanding supported by screening criteria but species presence not found in historical monitoring.
Barker Slough Pumping Plant/North Bay Aqueduct Operations	sDPS green sturgeon	Entrainment,	Juvenile/sub-adult (W. Delta)	Year-round presence	Altered migration; Entrainment; reduced growth	Minor to Sublethal	Very Small (<2%)	High - Annual operation of Barker Slough Pumping Plant and N. Bay Aqueduct	Low	Low - Conceptual understanding supported by screening criteria but species presence not found in historical monitoring.

7.5.1.16. Clifton Court Forebay Weed Management

DWR has proposed to apply herbicides and algaecides or use mechanical harvesters on an as-needed basis to control aquatic weeds and algal blooms in CCF. The preferred herbicides include Aquathol® K (applied at a concentration of up to 3 ppm), copper-based compounds (applied at a concentration of up to 1 ppm) and peroxygen-based algaecides (applied at a concentration up to 10.2 ppm hydrogen peroxide) to reduce the standing crop of the invasive aquatic weeds or algal blooms growing in the water body. The dominant species of aquatic weeds in the forebay change from year-to-year and can include Brazilian waterweed (*Egeria densa*), curly-leaf pondweed (*Potamogeton crispus*), sago pondweed (*Stuckenia pectinata*), and southern naiad (*Najas guadalupensis*), however, other native and invasive aquatic weeds are present as well. Excessive weeds fragment and clog the trash racks and fish screens of the Skinner Delta Fish Protective Facility, reducing operating efficiency and creating conditions in which the screens fail to comply with the appropriate flow and velocity criteria for the safe screening of listed fish. In addition, the weeds create sufficient blockage to the flow of water through the trash racks and louver array such that the pumps at the Banks Pumping Plant begin to reduce the water level downstream of the Skinner Delta Fish Protective Facility, and the loss of hydraulic head creates conditions that lead to cavitation of the impeller blades on the pumps if pumping rates are not quickly reduced. The algal blooms do not affect the pumps but rather reduce the quality of the pumped water by imparting a noxious taste and odor to the water, rendering it unsuitable for drinking. In addition, dense stands of aquatic weeds provide cover for unwanted predators that prey on listed species within the CCF.

DWR selects endothall-based herbicides when aquatic plant surveys indicate that pondweeds are the dominant species and copper-based herbicides when *Egeria* spp. are the dominant species (California Department of Water Resources 2023). Additionally, California Department of Water Resources (2023) states that since 2006, a mechanical harvester has been used to remove weeds near the outlet from CCF into the approach canal leading to the trash racks in front of the Skinner Delta Fish Protective Facility (California Department of Water Resources 2023). The harvester is used for the regular removal of pondweeds to help maintain flows to the Skinner Delta Fish Protective Facility and Banks Pumping Plant (California Department of Water Resources 2023).

Aquatic weed and algae treatments would occur on an as-needed basis depending upon the level of vegetation biomass, the cyanotoxin concentration from the harmful algal blooms, or the concentration of taste and odor compounds. Aquatic herbicides are ideally applied early in the growing season when plants are susceptible to them during rapid growth and formation of plant tissues, or later in the season when plants are mobilizing energy stores from their leaves towards their roots for overwintering senescence. DWR anticipates aquatic weed treatments (application of herbicides and algaecides or mechanical harvesters) to occur twice per year: once in early summer (late June to early July) and again in fall (mid to late October). The annual frequency of algal bloom treatments is less predictable under changing climatic conditions and public safety regulations. Based on past conditions, algal treatments are likely to average less than once per year over the next 10 years and may range from zero to two treatments per year. Algal bloom treatments may occur year-round but are most likely to occur during the summer and fall months. Treatment areas are typically about 900 acres and no more than 50 percent of the 2,180 total surface acres.

The DWR proposes to conduct the following application procedures:

- Apply peroxide-based aquatic algaecides, as needed, year-round.
- Apply Aquathol® K and copper-based aquatic pesticides, and use mechanical harvesters, as needed, from June 28 to October 31.
    - Treatments occurring between October 15 and October 31 will be associated with multi-day outages.
- Apply Aquathol® K and copper-based aquatic pesticides, as needed, prior to June 28 or after October 31 if the average daily water temperature within CCF is at or above 25°C and if Delta smelt, salmonids, and sDPS green sturgeon are not at additional risk from the treatment as confirmed by NMFS, USFWS, and CDFW.
    - At least 2 weeks prior to treatment, DWR will notify NMFS, USFWS, and CDFW on whether ESA-listed fish species are present and at risk from the proposed treatment.
- Monitor the salvage of listed fish at the Skinner Delta Fish Protective Facility prior to the application of the aquatic herbicides and algaecides in CCF.
- Prior to application of Aquathol® K and copper compounds, the radial intake gates will be closed at the entrance to CCF prior to the application of pesticides to allow fish to move out of the targeted treatment areas and toward the salvage facility and to prevent any possibility of aquatic pesticide diffusing into the Delta.
- For Aquathol® K and copper compounds, the radial gates will remain closed for a minimum of 12 hours up to approximately 75 hours after treatment to allow for the recommended duration of contact time between the aquatic pesticide and the treated vegetation or cyanobacteria in CCF and to reduce residual endothall concentrations for drinking water compliance purposes (contact time is dependent upon pesticide type, applied concentration, and weed or algae assemblage). Radial gates would be reopened after a minimum of 36 hours (24 hours pre-treatment closure plus 12 hours post-treatment closure).
- For peroxide-based algaecides, the radial gates will be closed prior to the application of the algaecide to prevent any possibility of the algaecide diffusing into the Delta. The radial gates may reopen immediately after the treatment as the required contact time is less than 1 minute, and there is no residual by-product of concern.
- The application will be made by a licensed applicator under the supervision of a California Certified Pest Control Advisor.
- Herbicides will be applied in a manner consistent with the label instructions, with a target concentration dependent upon the target species and biomass, water volume, and the depth of the forebay.
- Aquatic herbicides and algaecides will be applied by boat or by helicopter.
    - Boat applications will be by subsurface injection system for liquid formulations and boat-mounted hopper dispensing system for granular formulations. Applications would start at the shoreline and move systematically farther offshore, enabling fish to move out of the treatment area.
- Aerial applications of granular and liquid formulations will be by helicopter. No aerial spray applications will occur during wind speeds above 15 miles per hour to prevent spray drift.

- An application would be to the smallest area possible that provides relief to SWP operations or water quality. No more than 50 percent of CCF will be treated at one time.
- Water quality samples will be collected before, during, and after application to ensure concentrations within or adjacent to the treatment area do not exceed the application limit, per National Pollutant Discharge Elimination System (NPDES) permit requirements, will be collected. No monitoring of copper or endothall concentrations in the sediment or detritus is proposed.
- No monitoring of peroxide concentration in the water column will occur during and after application as the reaction is immediate and there is no residual.
- A spill prevention plan will be implemented in the event of an accidental spill.

If, for any reason, DWR needs to deviate in the conditions for the timing of herbicide application, herbicide product and intended application measures, potential for exposure of listed species, or implementation of described protective measures, DWR will provide a plan to USFWS, NMFS, and CDFW, copying Reclamation, identifying at a minimum:

- Conditions for the timing of herbicide application
- Herbicide product and intended application methods
- Potential for exposure of listed species
- Information on toxicity for listed species
- Additional protective measures to prevent or minimize adverse effects.

Upon receiving concurrence from USFWS, NMFS, and CDFW, which may include additional requirements, DWR may implement the plan. Upon completion of the plan, and no less frequently than annually, DWR will provide a letter to USFWS, NMFS, and CDFW, copying Reclamation, describing compliance with the plan and compliance with additional requirements imposed in the concurrence to the plan.

DWR proposes to implement additional protective measures to prevent or minimize adverse effects from herbicide applications. As described above, applications of aquatic herbicides and algaecides will be contained within CCF. Additionally, prior to aquatic herbicide applications following gate closures, the water will be drawn down in the CCF via the Banks Pumping Plant. This drawdown helps facilitate the movement of fish in the CCF toward the fish diversion screens and into the fish protection facility, lowers the water level in the CCF to decrease the total amount of herbicide needed to be applied per volume of water, and aides in the dilution of any residual pesticide post-treatment.

7.5.1.16.1. Assess the Species Exposure

The timing of the application of the aquatic herbicides (Aquathol® K, chelated copper herbicides, and copper carbonate compounds) and mechanical harvesting in the waters of CCF will normally occur during the summer and fall months. Some exceptions outside of this timeframe are proposed on an “as needed basis” after DWR confirms with NMFS and USFWS, and it is determined that listed fish are not present in CCF. The probability of exposing salmonids to the endothall- or copper-based herbicides or harvesters during the normal summer and fall application period is very low due to the life history of Chinook salmon and CCV steelhead in the Delta region. Migrations of juvenile SR winter-run Chinook salmon and CV

spring-run Chinook salmon primarily occur outside of the July 1 through October 31 period in the Delta. California Central Valley steelhead have a very low probability of being in the South Delta during the period proposed for herbicide treatments. Historical salvage data indicate that in wet years, a few CCV steelhead may be salvaged as late as early July, but this is uncommon, and the numbers are based on a few individuals in the salvage collections. Based on typical water temperatures in the vicinity of the salvage facilities during this period, the temperatures would be incompatible with salmonid life history preferences. Migrations of juvenile SR winter-run Chinook salmon and CV spring-run Chinook salmon primarily occur outside of the July 1 through October 31 period in the Delta. California Central Valley steelhead have a low probability of being in the South Delta during late June when temperatures exceed 25°C through August (Grimaldo et al. 2009). In contrast, juvenile and subadult sDPS green sturgeon are recovered year-round at the CVP and SWP fish salvage facilities and have higher levels of salvage during the months of July and August compared to the other months of the year. The reason for this distribution is unknown. Therefore, juvenile and subadult sDPS green sturgeon are likely to be present during the application of the herbicides or mechanical harvesting.

7.5.1.16.2. Assess Species Response to the Application of Herbicides and Algaecides

7.5.1.16.2.1. Copper-Based Herbicides and Algaecides

When aquatic plant survey results indicate that *E. densa* is the dominant species, copper-based compounds will be selected due to their effectiveness in controlling this species. Previous applications of copper-based herbicides (Komeen® and Nautique®) have followed the label directions of the product, which limits copper concentration in the water to 1,000 µg/L (1 ppm or 1,000 ppb). The copper in some of the copper-based herbicides is chelated, meaning that it is sequestered within the molecule and is not fully dissociated into the water upon application. Therefore, not all of the copper measured in the water column is biologically available at the time of application. DWR proposes to apply copper herbicides and algaecides in a manner consistent with the label instructions, with a target concentration dependent upon target species and biomass, water volume, and the depth of CCF. Applications of copper herbicides for aquatic weed control will be applied at a concentration of 1 ppm with an expected dilution to 0.75 ppm upon dispersal in the water column. Applications for algal control will be applied at a concentration of 0.2 to 1 ppm with expected dilution within the water column. DWR will monitor dissolved copper concentration levels during and after treatment to ensure levels do not exceed the application limit of 1 ppm, per NPDES permit required procedures. Treatment contact time will be up to 24 hours. If the dissolved copper concentration falls below 0.25 ppm during an aquatic weed treatment, DWR may opt to open the radial gates after a minimum of 36 hours to resume operations (24 hours pre-treatment closure plus 12 hours post-treatment closure). Opening the radial gates prior to 24 hours would enable the rapid dilution of residual copper and thereby shorten the exposure duration of the treatment to ESA-listed fish present in CCF. No more than 50 percent of the surface area of CCF will be treated at one time.

Toxicity studies conducted by California Department of Fish and Game (2004) measured the concentrations of a chelated copper herbicide (Komeen®) that killed 50 percent of the exposed population over 96 hours (96 hr-LC50 [Lethal Concentration for 50 percent of the organisms]) and 7 days (7d LC50) as well as determining the maximum acceptable toxicant concentration level to exposed organisms. CDFG found that the 96 hr-LC50 for fathead minnows (*Pimephales*

promelas) was 0.31 ppm (0.18 to 0.53 ppm 95 percent confidence limit), and the 7d- LC50 was 0.19 ppm. The maximum acceptable toxicant concentration level was calculated as 0.11 ppm Komeen® in the water column. Splittail (*Pogonichthys macrolepidotus*), a native cyprinid minnow, was also tested by CDFG. The 96 hr-LC50 for splittail was 0.51 ppm.

Toxicity studies by Wagner et al. (2017) measured concentrations of a copper carbonate compound (Nautique®) that negatively affected 50 percent of the exposed population over 96 hours (96 hr-EC50) and 96 hr-LC50. Wagner et al. (2017) found that for brook trout (*Salvelinus fontinalis*), the 96 hr-EC50 was 26.2 ppm and the 96 hr-LC50 was 28.2 ppm. The same study found that for fathead minnows, the 96 hr-EC50 and 96 hr-LC50 were 23.0 ppm and 24.4 ppm at 22°C and 19.6 and 19.7 ppm at 28°C, respectively. These values indicate that certain copper carbonate compounds may have higher toxicity at elevated water temperatures (Wagner et al. 2017).

NMFS did not find toxicity data for exposure of sDPS green sturgeon to copper-based herbicides; however, exposure to other compounds, including pesticides and copper, were found in the literature (Dwyer et al. 2000, Dwyer et al. 2005a, Dwyer et al. 2005b). From these studies, sturgeon species appeared to have sensitivities to contaminants comparable to salmonids and other highly sensitive fish species. Therefore, NMFS will assume that sDPS green sturgeon will respond to copper-based herbicides in a fashion similar to that of salmonids and should have similar mortality and morbidity responses. Pacific salmonids are very susceptible to copper toxicity, having the lowest LC50 threshold of any group of freshwater fish species tested by the EPA in their Biotic Ligand Model (EPA 2003) with a Genus Mean Acute Value of 29.11 ppb of copper. In comparison, fathead minnows, the standard EPA test fish for aquatic toxicity tests, have a Genus Mean Acute Value of 72.07 ppb of copper. Therefore, salmonids are approximately three times more sensitive to copper than fathead minnows. NMFS assumes that sDPS green sturgeon will have a similar level of sensitivity. Hansen et al. (2002) exposed rainbow trout to sub-chronic levels of copper in water with a nominal water hardness of 100 mg/L (as calcium carbonate). Growth, whole-body copper concentrations, and mortality were measured over an 8-week trial period. Significant mortality occurred in fish exposed to 54.1 ppb copper (47.8 percent mortality) and 35.7 ppb copper (11.7 percent mortality). Growth and body burden of copper were also dose-dependent with a 50 percent depression of growth occurring at 54.0 ppb, but with significant depressions in growth still occurring at copper doses as low as 14.5 ppb after the 8-week exposure (Hansen et al. 2002).

In a separate series of studies, Hansen et al. (1999a) and Hansen et al. (1999b) examined the effects of low-dose copper exposure to the electrophysiological and histological responses of rainbow trout and Chinook salmon olfactory bulbs and the two fish species' behavioral avoidance response to low-dose copper. Chinook salmon were shown to be more sensitive to dissolved copper than rainbow trout and avoided copper levels as low as 0.7 ppb copper (water hardness of 25 mg/L), while the rainbow trout avoided copper at 1.6 ppb. Diminished olfactory (i.e., taste and smell) sensitivity reduces the ability of the exposed fish to detect predators and to respond to chemical cues from the environment, including the imprinting of smolts to their home waters, avoidance of chemical contaminants, and diminished foraging behavior (Hansen et al. 1999b). The olfactory bulb electroencephalogram responses to the stimulant odor, L-serine, were completely eliminated in Chinook salmon exposed to 50 ppb copper and in rainbow trout exposed to 200 ppb copper within 1 hour of exposure. Following copper exposure, the

electroencephalogram response recovery to the stimulus odor was slower in fish exposed to higher copper concentrations. Histological examination of Chinook salmon exposed to 25 ppb copper for 1 and 4 hours indicated a substantial decrease in the number of receptors in the olfactory bulb due to cellular necrosis. Similar receptor declines were seen in rainbow trout at higher copper concentrations during the 1-hour exposure and were nearly identical after 4 hours of exposure. A more recent olfactory experiment (Baldwin et al. 2003) examined the effects of low-dose copper exposure on coho salmon and their neurophysiological response to natural odorants. The inhibitory effects of copper (1.0 to 20.0 ppb) were dose-dependent and were not influenced by water hardness. Declines in sensitivity were apparent within 10 minutes of the initiation of copper exposure and maximal inhibition was reached in 30 minutes. The experimental results from the multiple odorants tested indicated that multiple olfactory pathways are inhibited and that the thresholds of sublethal toxicity were only 2.3 to 3.0 ppb above the background dissolved copper concentration. The results of these experiments indicate that even when copper concentrations are below lethal levels, substantial negative effects occur to salmonids exposed to these low levels. Reduction in olfactory response is expected to increase the likelihood of morbidity and mortality in exposed fish by impairing their homing ability and, consequently, migration success, as well as by impairing their ability to detect food and predators. In addition, NMFS issued a technical paper on copper toxicology (Hecht et al. 2007). Given that sDPS green sturgeon use their sense of smell and tactile stimulus to find food within the bottom substrate, degradation of their olfactory senses could diminish their effectiveness at foraging and compromise their physiological condition through decreases in caloric intake following copper exposure.

In addition to these physiological responses to copper in the water, Sloman et al. (2002) found that the negative effect of copper exposure was also linked to the social interactions of salmonids. Subordinate rainbow trout in experimental systems had elevated accumulations of copper in both their gill and liver tissues, and the level of adverse physiological effects was related to their social rank in the hierarchy of the tank. The increased stress levels of subordinate fish, as indicated by stress hormone levels, are presumed to lead to increased copper uptake across the gills due to elevated ion transport rates in chloride cells. Furthermore, excretion rates of copper may also be inhibited, thus increasing the body burden of copper. Sloman et al. (2002) concluded that not all individuals within a given population will be affected equally by the presence of waterborne copper and that the interaction between dominant and subordinate fish will determine, in part, the physiological response to the copper exposure. It is unknown how social interactions affect juvenile and subadult sDPS green sturgeon in the wild.

Current EPA National Recommended Water Quality Criteria and the California Toxics Rule standards promulgate a chronic maximum concentration of 5.9 µg/L and a continuous concentration criteria of 4.3 µg/L for copper in its ionized form (EPA 2000). The data from the toxicity studies mentioned above indicate that a maximum working concentration of 1.0 ppm metallic copper will be toxic to salmonids if they are present, either causing death or severe physiological degradation and, therefore, sDPS green sturgeon would likely be similarly affected based on their similar sensitivities to copper toxicity.

7.5.1.16.2.2. Aquathol® K

Aquathol® K is registered for use in California and has effectively controlled pondweeds and southern naiad in CCF and in other lakes. It is available in both liquid and granular formulations. Aquathol® K, the liquid formulation of dipotassium salt of endothall, consists of 40.3 percent of 7-oxabicyclo[2.2.1]heptane-2,3-dicarboxylic acid equivalent to 28.6 percent, which is equivalent to 4.23 pounds of active ingredient per gallon of product. The active ingredient in Aquathol® K is dipotassium salt of endothall. Endothall is an herbicide in the dicarboxylic acid chemical class. While its exact mode of action is unknown, hypotheses include cellular disruption, possibly including interference with protein or lipid synthesis or disrupting the transport of nutrients across cell membranes (Tresch et al. 2011). The potential for bioaccumulation is not fully known. The USFS estimates that endothall may have a modest potential for mammalian bioaccumulation (Syracuse Environmental Research Associates Inc. (SERA) 2009), but studies indicate that bioaccumulation in fish is unlikely (Wisconsin Department of Natural Resources 2012).

The EPA-approved endothall as a reduced-risk herbicide. DWR is proposing to use the dipotassium salt formulation of endothall (as Aquathol® K) and not the amine salt (Hydrothol) formulations, which are highly toxic to fish and invertebrates bioaccumulation (Syracuse Environmental Research Associates Inc. (SERA) 2009). The fish acute and chronic toxicity endpoints for endothall relevant to ESA-listed species include LC50s for Chinook salmon range from 23 ppm to greater than 150 ppm and greater than 100 ppm for coho salmon. One study (Courter et al. 2012) of the effect of Cascade®, an herbicide with the same endothall formulation as Aquathol® K, on salmon and steelhead smolts showed no sublethal effects until exposed to 9 to 12 ppm. A study on the ecotoxicity of endothall commissioned by the California Division of Boating and Waterways from 2014 to 2017 reported a wide range of acute effects to fish species ranging from No Observable Effect Concentration (NOEC) for growth and survival effects at the highest concentration tested (NOEC greater than 500 ppm) for rainbow trout. Figure 154 provides an illustration of endothall estimated Effects Concentration, LC50, NOEC, and Lowest Observable Effect Concentration levels for reptile surrogate and fish species. The NPDES permit limit for endothall in receiving waters is 100 ppb. The lowest chronic fish endpoint observed is an impaired weight for the fathead minnow at 3.1 ppm and NOEC for Chinook salmon at approximately 3.5 ppm.

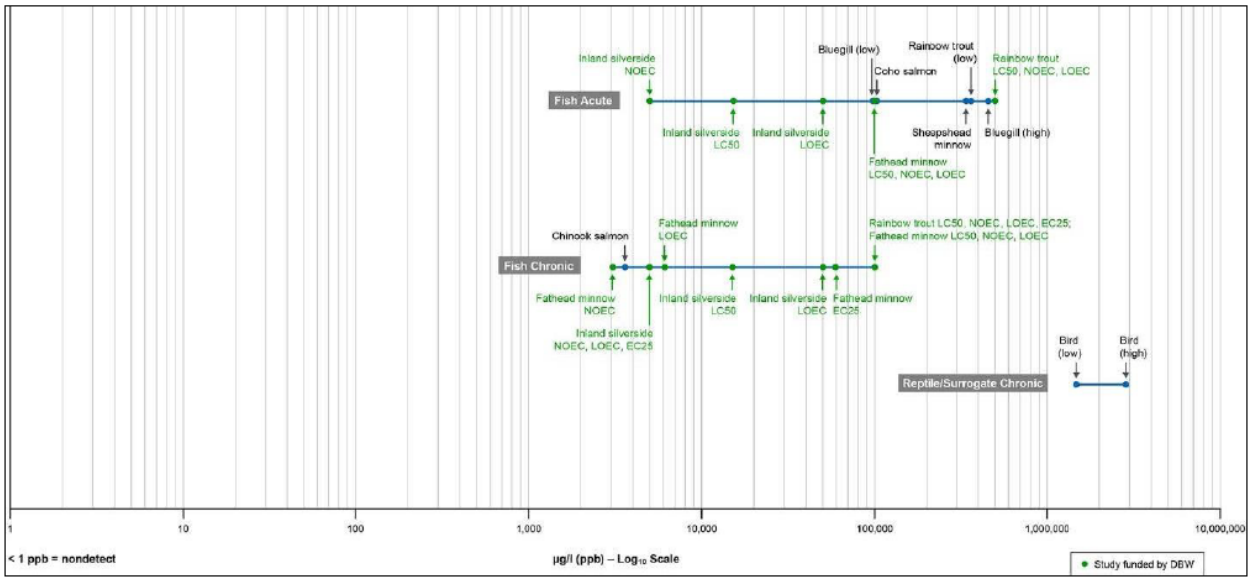


Figure 154. Exposure concentrations for surrogate and fish species endpoint effects for endothall (µg/L or parts per billion [ppb]).

Source:(California Division of Boating and Waterways and U.S. Department of Agriculture - Agricultural Research Service 2017)

When aquatic plant survey results indicate that pondweeds are the dominant species in CCF, Aquathol® K will be selected due to its effectiveness in controlling these species. Aquathol® K will be applied according to the label instructions, with a target concentration dependent upon plant biomass, water volume, and CCF depth. Aquathol® K labeling (Aquathol Safety Data Sheet) recommends 0.75 ppm to 3.0 ppm for pondweeds. The target concentration of treatments DWR proposes is 2 to 3 ppm. Additionally, the duration of exposure to endothall for listed fish will be approximately 12 to 24 hours. A minimum contact time of 12 hours is needed for biological uptake and treatment effectiveness, but the contact time may be extended up to approximately 75 hours after treatment to reduce the residual endothall concentration for NPDES compliance purposes. DWR will monitor herbicide concentration levels during and after treatment to ensure levels do not exceed the Aquathol® K application limit of 5 ppm. Additional water quality testing may occur following treatment for drinking water intake purposes. Samples are submitted to a laboratory for analysis. Radial gates may reopen after a minimum of 36 hours (24 hours pre-treatment closure plus 12 hours post-treatment closure). No more than 50 percent of the surface area of CCF will be treated at one time. Due to the lack of data on the effects of Aquathol® K to surrogates for sDPS green sturgeon, NMFS will assume that sDPS green sturgeon will respond to Aquathol® K in a fashion similar to that of salmonids and should have similar mortality and morbidity responses. Chinook salmon are affected at low concentrations by endothall and display acute and chronic effects to endpoints at various life stages (juvenile growth and survival are within the range of maximum application concentration). NMFS assumes that sDPS green sturgeon will have a similar level of sensitivity and are likely to experience negative physiological effects (i.e., reduced growth and survival) and vulnerability to predation as a result of endothall exposure.

7.5.1.16.2.3. Peroxygen-Based Algaecides

The PAK 27 algaecide active ingredient is sodium carbonate peroxyhydrate. An oxidation reaction occurs immediately upon contact with the water, destroying algal cell membranes and chlorophyll. There is no contact or holding time requirement, as the oxidation reaction occurs immediately, and the byproducts are hydrogen peroxide and oxygen. There are no fishing, drinking, swimming, or irrigation restrictions following the use of this product. PAK 27 has NSF/ANSI Standard 60 Certification for use in drinking water supplies at maximum-labeled rates and is certified for organic use by the Organic Materials Reviews Institute. PAK 27, or an equivalent product, will be applied in a manner consistent with the label instructions, with permissible concentrations in the range of 0.3 to 10.2 ppm hydrogen peroxide.

NMFS did not find toxicity data for exposure of salmonids or sturgeon to peroxygen-based algaecides. In a single study for fathead minnows, the 96hr-NOEC was 7.4 ppm, and the LC50 was 71 ppm. These data reflect low toxicity effects on fish. Due to the lack of data on the effects of peroxygen-based algaecides to surrogates for ESA-listed salmonids or sDPS green sturgeon, NMFS will assume that they will respond to peroxygen-based algaecides in a fashion similar to that of fathead minnows and should have similar mortality and morbidity responses. Fathead minnows are only affected at very high concentrations by peroxygen-based algaecides. NMFS assumes that salmonids and sDPS green sturgeon will have a similar level of sensitivity and are not likely to experience negative physiological effects as a result of exposure. Therefore, there are no anticipated direct impacts on ESA-listed fish with the use of peroxygen-based aquatic algaecides in CCF. However, it should be noted that decaying algae, killed by peroxygen-based algaecides, can deplete dissolved oxygen levels in the water, which could result in fish mortality. Because the frequency of algaecide applications to control harmful algal blooms is not expected to occur more than once every few years, and no more than 50 percent of the surface area of CCF will be treated at one time, it is unlikely that algal decomposition will lead to sufficient oxygen depletion to result in fish mortality.

7.5.1.16.2.4. Mechanical Harvesting

DWR proposes to continue using boat-mounted aquatic weed harvesters to manually remove aquatic weeds in the CCF on an as-needed basis. Harvesters are needed year-round, with peak use occurring in late summer and fall when aquatic weed stands are most dense and during periods of hyacinth entrainment. The objective is to decrease the weed load on the trash racks and to improve flows in the channel. Effectiveness is limited due to the sheer volume of aquatic weeds and the limited capacity and speed of the harvesters. Harvesting rates for a typical weed harvester range from 0.5 to 1.5 acres per hour or 4 to 12 acres per day. Actual harvest rates may be lower due to travel time to off-loading sites, unsafe field conditions such as high winds, and equipment maintenance. DWR implements protective measures during aquatic weed harvesting to avoid and minimize potential impacts on sensitive resources.

DWR proposes the following operating procedures:

- Aquatic weed harvesters may be operated on an as-needed basis, year-round
- Weed harvesting areas include the CCF and the intake channel upstream of the trash racks and louvers

- All on-site personnel participate in environmental awareness training for special-status species with the potential to occur in the project area
- If any wildlife is observed within the aquatic weed removal and disposal areas, work is halted immediately, and the wildlife are allowed to move out of the area on their own
- Aquatic weed disposal and vehicle travel are contained within the established roadways and identified work area
- The harvested aquatic weeds are stockpiled on land for transport to a commercial green waste facility or similar facility

Mechanical aquatic weed control activities associated with the use of harvesters, booms, and automated rakes are likely to result in various stressors (e.g., conveyor mechanism and bycatch, increased turbidity, and low dissolved oxygen), which could increase the likelihood of negative effects to salmonids and sDPS green sturgeon in the form of injury, mortality, avoidance activity, gill fouling, and reduced forging capability. The potential for direct and indirect effects to listed species as a result of mechanical removal methods depends on the magnitude (duration and frequency of exposure) of disturbance, the type of method used, and the presence and proximity of listed species in the treatment site. Potential effects of the operation of automated rakes include mortality or injury from contact with the rake, entrapment, removal from water, and temporary disturbance. Automated rakes have the potential to indirectly and directly affect (i.e., injure or kill) listed species if the species are collected along with the aquatic weeds. The operation of a hydraulic rake cleaning system has been shown to trap and kill adult Chinook salmon and other non-listed fish (U.S. Bureau of Reclamation 2016).

Harvesters, cutters, and shredders have the potential to indirectly (i.e., alter feeding behavior and foraging of prey items) and directly affect (i.e., injure or kill) listed species due to the mechanics of the cutting equipment and, for harvesters, the conveyor belt systems that will be used to remove biomass (and any potential bycatch) from the water. Engel (1995) found that harvesting also has the potential for direct and indirect effects by removing macroinvertebrates, aquatic vertebrates, forage fishes, young-of-the-year fishes, and game fishes. Additionally, fragmentation caused by cutting may spread invasive plant infestations, and both harvesting and cutting may suspend sediments, temporarily increasing turbidity (Madsen 2000). Madsen (2000) showed that these methods may release nutrients. This finding is supported by James et al. (2000) who determined that shredding had mixed effects on nutrients and dissolved oxygen-plant decomposition tended to increase biochemical oxygen demand and nutrient cycling, but this was offset by increases in algal productivity and the increase in oxygen caused by the shredding machine's mixing of the water.

7.5.1.16.3. Summary of the Effects of the Clifton Court Forebay Weed Management

The proposed mechanical harvest program's normal period of application (June 28 through October 31) will substantially avoid the presence of listed salmonids in the CCF due to the run timing of the juveniles through the Delta. As described earlier, CCV steelhead smolts may arrive during any month of the year in the Delta, but their likelihood of occurrence is considered very low during the proposed treatment period. It is also highly unlikely that any SR winter-run Chinook salmon or CV spring-run Chinook salmon will be present during this time period in the South Delta. Unlike the salmonids, however, sDPS green sturgeon have been salvaged during the summer at both the CVP and SWP fish salvage facilities. This is related to their year-round

residency in the Delta during their first 3 years of life. It is, therefore, likely that individuals from the sDPS green sturgeon will be exposed to the endothall and/or copper herbicides and mechanical harvesting activity, and, based on the comparative sensitivities of sturgeon species with salmonids, some of these fish are likely to be killed or otherwise negatively affected. The exact number of fish exposed is impossible to quantify since the density of sDPS green sturgeon residing or present in CCF at any given time is unknown. The short duration of treatment and rapid flushing of the system will help to ameliorate the adverse conditions created by the herbicide treatment.

The application of herbicides and mechanical harvesting in CCF under the Aquatic Weed Control Program will not affect the populations of SR winter-run Chinook salmon or CV spring-run Chinook salmon. These populations of salmonids do not occur in the South Delta during the proposed period of herbicide applications and, thus, exposure to individuals is very unlikely. Since no individual fish are exposed, population-level effects are absent. Exposure of CCV steelhead is also very unlikely; however, some individual fish may be present during July as indicated by the historical salvage record, and, thus, the occurrence of fish in CCF during the harvesting and/or herbicide treatments is not impossible. The number of CCV steelhead that will be exposed to the harvesting and herbicides is believed to be very small, and therefore, demonstrable effects at the population level resulting from exposure are unlikely.

The effects to the sDPS green sturgeon population are much more ambiguous due to the lack of information regarding the status of the population in general. Although NMFS estimates that few sDPS green sturgeon will be exposed during the mechanical harvesting and herbicide treatments, the relative percentage of the population this represents is unknown. Likewise, NMFS expects the number of sDPS green sturgeon that reside in CCF at any given time and their susceptibility to entrainment to be small.

Table 142 summarizes the individual species analysis of exposure and response associated with the consequences of the proposed action element Clifton Court Forebay Weed Management.

Table 142. Information used to identify effects of the proposed action from Clifton Court Forebay Weed Management on species.

Proposed Action element	Species	Stressors	Life Stage (Location)	Life Stage Timing (Work Window Intersection)	Individual Response and Rationale of Effect	Severity of Stressor	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence
Clifton Court Forebay Weed Management	California Central Valley steelhead	Water quality, mechanical entrainment	Juvenile (S. Delta)	July and September (July and September)	Altered migration; increased risk to predation, entrainment; reduced migration success, increased risk of mortality	Sublethal to Lethal	Small (<2%)	Low - Annual weed removal but infrequent application of harmful concentrations	Medium	Medium - multiple studies of herbicide toxicity, but relatively low certainty of species presence.
Clifton Court Forebay Weed Management	sDPS green sturgeon	Water quality, mechanical entrainment	Adult (S. Delta)	Year-round presence (July - October)	Altered migration; Entrainment; reduced spawning success; mortality	Sublethal to Lethal	Medium	Medium - Annual weed removal but infrequent application of harmful concentrations	Low	Medium - multiple studies of herbicide toxicity, but relatively low certainty of species presence.
Clifton Court Forebay Weed Management	sDPS green sturgeon	Water quality, mechanical entrainment	Juvenile/sub-adult (S. Delta)	Year-round presence (July - October)	Altered migration, Entrainment; reduced growth, mortality	Sublethal to Lethal	Medium	Medium - Annual weed removal but infrequent application of harmful concentrations	Low	Medium - multiple studies of herbicide toxicity, but relatively low certainty of species presence.

7.5.1.17. B.F. Sisk Dam Raise and Reservoir Expansion

The proposed action includes operations of the CVP and SWP with an additional 130 TAF of CVP storage in San Luis Reservoir that results from raising B.F. Sisk Dam and increasing the size of San Luis Reservoir. Appendix F, Attachment 1-2 - Callouts Table (U.S. Bureau of Reclamation 2023-2024) describes more specifically that the storage increase in the proposed action increases the CVP share of San Luis Reservoir capacity to 1102 TAF (compared to the current CVP share of 972 TAF), while the SWP share (reported as 1067 TAF in the description of the NAA scenario in Appendix F, Attachment 1-1 in U.S. Bureau of Reclamation 2023-2024) will remain the same. The proposed action mentions only a 12-foot raise of the dam, but as described on pages 2-40 to 2-41 of the 2019 BA (U.S. Bureau of Reclamation 2019b), in the Environmental Baseline section, there are actually two B.F. Sisk Dam raises expected. One raise, of 12 feet, is associated with the B.F. Sisk Dam Safety of Dams Modification Project—this project allows for safer operation to current storage levels in San Luis Reservoir (U.S. Bureau of Reclamation 2019a). The additional raise, of 10 feet, is associated with the B.F. Sisk Dam Raise and Reservoir Expansion Project and is the project element that increases San Luis Reservoir storage by 130 TAF. The construction elements of the projects are consulted on separately with USFWS (no NMFS consultation required) and are part of the environmental baseline. The *operational* effects of the expanded storage are consulted on as part of this proposed action.

For some context as to the effects of the reservoir expansion on export changes, distinct from export changes due to other proposed action elements such as OMR management or Spring Delta Outflow, NMFS has evaluated the number of months during the 100-year CalSim period of record (water years 1922–2021) that CVP San Luis Reservoir storage exceeded the current CVP share capacity of 972 TAF. This evaluation indicates when and how often South Delta exports increased in Alt2v1 and Alt2v2 relative to the NAA scenario due to the increased storage in San Luis Reservoir.

The Alt2v1 scenario had 114 months (10 percent of the 1200 months in the CalSim period of record) for which CVP San Luis Reservoir storage exceeded 972 TAF, which occurred during 32 different years. Unsurprisingly, the additional storage (and associated exports) was most frequent in February through May (Table 143), when San Luis Reservoir storage tends to be highest, since it is after much of the winter precipitation but still before much of the year's water deliveries. Across all 114 months, the additional storage above 972 TAF ranged between 0.5 TAF and 130 TAF, with an average of 93 TAF. Forty-four of the 114 months (39 percent) used the full 130 TAF of additional capacity within the CVP share of San Luis Reservoir.

Because Alt2v2 includes additional export reductions in the Delta compared to Alt2v1, one might expect the frequency and amount of additional exports due to increased capacity at San Luis Reservoir to be less than that estimated under Alt2v1. While the results do generally support those expected directional trends, the differences between Alt2v2 and Alt2v1 are quite small since the increased San Luis Reservoir capacity is most likely to matter in wet water years, when there is no commitment to Delta VA-related export reductions in Alt2v2. The Alt2v2 scenario had 114 months (10 percent of the 1200 months in the CalSim period of record) for which CVP San Luis Reservoir storage exceeded 972 TAF, which occurred during 31 different years. As in Alt2v1, the additional storage (and associated exports) was most frequent in February through May (Table 143). Across all 114 months, the additional storage above 972 TAF ranged between 0.3 TAF and 130 TAF, with an average of 91 TAF. Forty-three of the 114 months (38 percent) used the full 130 TAF of additional capacity within the CVP share of San Luis Reservoir.

Table 143. Number of times during the 100-year CalSim period of record (water years 1922–2021) that, for the Alt2v1 and Alt2v2 scenarios, the month's Central Valley Project (CVP) San Luis Reservoir storage exceeded the current CVP share capacity of 972 thousand acre-feet (TAF). This indicates when and how often South Delta exports increased relative to the No Action Alternative scenario.

Month	Alt2v1: Count of months during which CVP San Luis Reservoir storage exceeded 972 TAF	Alt2v2: Count of months during which CVP San Luis Reservoir storage exceeded 972 TAF
October	1	1
November	1	1
December	3	3
January	8	8
February	15	15
March	27	27
April	31	31
May	22	21
June	6	7
July	0	0
August	0	0
September	0	0
Total	**114**	**114**

The increased reservoir capacity allows for increased South Delta exports in Alt2v1 (and, to a lesser degree, in Alt2v2). The associated disruptions to South Delta hydrodynamics is expected to affect through-Delta survival for listed salmonids and sturgeon relative to the NAA without the increased reservoir capacity. While NMFS is able to partially quantify the export changes due to increased reservoir capacity based on the evaluation summarized in Table 143, it is not possible to isolate the specific effects of the increased reservoir capacity in most lines of evidence presented in the BA. The effects from the additional 130 TAF of CVP storage in San Luis Reservoir are included in the overall Delta hydrodynamic conditions and biological modeling outcomes discussed in Section 7.5.1.3 (Delta Effects Lines of Evidence) and are covered under the analysis for OMR Management (Section 7.5.1.6) and Spring Delta Outflow (Section 7.5.1.7). NMFS relies on the effects to species described in those sections) to capture the impacts of export operations under the proposed action, and no further species-specific effects analysis is provided here.

7.5.1.18. Summary of Effects

The summary tables below describe the life stages, primary stressors and effect pathways, and relevant management actions for each operational season in the Delta for SR winter-run Chinook salmon (Table 144), CV spring-run Chinook salmon (Table 145), CCV steelhead (Table 146), and sDPS green sturgeon (Table 147). The purpose of Table 144 through Table 147 is to succinctly summarize the primary consequences of the proposed action without comparison to other scenarios or conditions. These effects that are summarized in Table 144 through Table 147 will also be carried forward to the Integration and Synthesis section of the opinion.

Table 144. Sacramento River winter-run Chinook salmon summary of primary affected life stages, primary stressors/effect pathways, and relevant management actions for seasonal operations periods. These are the elements that will be incorporated into the Integration and Synthesis section of the opinion.

Division/Water body	Seasonal Operations Period	Affected Life Stage	Summary of Primary Stressors and Effects of the Proposed Action	Relevant Management Actions
Delta	Summer and Fall Operations	Juvenile rearing and out-migration	Routing and entrainment risk at the Delta Cross Channel ● Risk of entrainment at Delta Cross Channel in November for early migrating juveniles when gates open	Delta Cross Channel Closures, technical and policy team coordination during real-time operations, and adaptive management
Delta	Summer and Fall Operations	Juvenile rearing and out-migration	Routing into Central and South Delta and entrainment at export facilities ● Risk of routing and entrainment in November for early migrating juveniles	OMR (Old and Middle rivers) Flow Management (winter-run early season migration action)
Delta	Winter and Spring Operations	Juvenile rearing and out-migration	Routing and entrainment risk at the Delta Cross Channel ● Risk of entrainment at Delta Cross Channel from December 1 to January 31 if gates are opened for D-1641 water quality actions	

Division/Water body	Seasonal Operations Period	Affected Life Stage	Summary of Primary Stressors and Effects of the Proposed Action	Relevant Management Actions
Delta	Winter and Spring Operations	Juvenile rearing and out-migration	Routing and entrainment risk into the Central and South Delta ● Risk of salvage and loss at the state and federal export facilities ● Risk of predation and other sources of mortality in the entrainment footprint ● Potential risk from implementing the storm flex action	OMR Flow Management ● Juvenile Production Estimate as tool for scaling loss triggers to population size ● Winter-run Early Season Migration Action ● Start of OMR Management ● Real-time adjustments ● Weekly distributed loss thresholds ● Seasonal loss thresholds ● Storm flex protective criteria
Delta	Winter and Spring Operations	Juvenile rearing and out-migration	Spring Delta Outflow ● Potential to use this action to reduce entrainment risk	Spring Delta Outflow Action and governance through technical and policy teams to schedule volumes

Table 145. Central Valley spring-run Chinook salmon summary of primary affected life stages, primary stressors/effect pathways, and relevant management actions for seasonal operations periods. These are the elements that will be incorporated into the Integration and Synthesis section of the opinion.

Division/Water body	Seasonal Operations Period	Affected Life Stage	Summary of Primary Stressors and Effects of the Proposed Action	Relevant Management Actions
Delta	Summer and Fall Operations	Juvenile rearing and out-migration	Routing and entrainment risk at the Delta Cross Channel ● Risk of entrainment at Delta Cross Channel in November for early migrating yearlings when gates open	Delta Cross Channel Closures, technical and policy team coordination during real-time operations, and adaptive management
Delta	Summer and Fall Operations	Juvenile rearing and out-migration	Routing into Central and South Delta and entrainment at export facilities ● Risk of routing and entrainment in November for early migrating juveniles	Yearling Central Valley spring-run Chinook salmon surrogates

Division/Water body	Seasonal Operations Period	Affected Life Stage	Summary of Primary Stressors and Effects of the Proposed Action	Relevant Management Actions
Delta	Winter and Spring Operations	Juvenile rearing and out-migration	Routing and entrainment risk at the Delta Cross Channel ● Risk of entrainment at Delta Cross Channel from December 1 to January 31 if gates are opened for D-1641 water quality actions ● Risk of entrainment at Delta Cross Channel when gates are opened for a total of 14 days from May 21 to June 15	Delta Cross Channel Closures, technical and policy team coordination during real-time operations, and adaptive management
Delta	Winter and Spring Operations	Juvenile rearing and out-migration	Routing and entrainment risk into the Central and South Delta ● Risk of salvage and loss at the state and federal export facilities ● Risk of predation and other sources of mortality in the entrainment footprint ● Potential risk from implementing the storm flex action	OMR (Old and Middle rivers) Flow Management ● Yearling Central Valley spring-run Chinook salmon surrogates ● Young-of-year Central Valley spring-run Chinook salmon surrogates ● Future use of a Juvenile Production Estimate as tool for scaling loss triggers to population size ● Start of OMR Management ● Real-time adjustments ● Storm flex protective criteria
Delta	Winter and Spring Operations	Juvenile rearing and out-migration	Spring Delta Outflow ● Potential to use this action to reduce entrainment risk	Spring Delta Outflow Action and governance through technical and policy teams to schedule volumes
Delta	Winter and Spring Operations	Juvenile rearing and out-migration	Agricultural Barrier Operations ● Passage impediments increase exposure to predation in May and June	Technical and policy team coordination

Table 146. California Central Valley steelhead summary of primary affected life stages, primary stressors/effect pathways, and relevant management actions for seasonal operations periods. These are the elements that will be incorporated into the Integration and Synthesis section of the opinion.

Division/Water body	Seasonal Operations Period	Affected Life Stage	Summary of Primary Stressors and Effects of the Proposed Action	Relevant Management Actions
Delta	Summer and Fall Operations	Juvenile rearing and out-migration	Routing and entrainment risk at the Delta Cross Channel ● Risk of entrainment at Delta Cross Channel in summer and fall for very low numbers of juveniles when gates open	Delta Cross Channel Closures, technical and policy team coordination during real-time operations, and adaptive management
Delta	Summer and Fall Operations	Juvenile rearing and out-migration	Routing into Central and South Delta and entrainment at export facilities ● Risk of routing and entrainment for very low numbers of juveniles	Annual loss thresholds and technical and policy team coordination during real-time operations
Delta	Winter and Spring Operations	Juvenile rearing and out-migration	Routing and entrainment risk at the Delta Cross Channel ● Risk of entrainment at the Delta Cross Channel from December 1 to January 31 if gates are opened for D-1641 water quality actions. ● Risk of entrainment at the Delta Cross Channel when gates are opened for a total of 14 days from May 21 to June 15.	

Division/Water body	Seasonal Operations Period	Affected Life Stage	Summary of Primary Stressors and Effects of the Proposed Action	Relevant Management Actions
Delta	Winter and Spring Operations	Juvenile rearing and out-migration	Routing and entrainment risk at the state and federal export facilities ● Risk of salvage and loss at the state and federal export facilities ● Risk of predation and other sources of mortality in the entrainment footprint ● Potential risk from implementing the storm flex action	OMR (Old and Middle rivers) Flow Management ● Start of OMR Management ● Real-time adjustments ● Storm flex protective criteria ● Annual Loss Thresholds ● Weekly Distributed Loss Thresholds ● Storm flex protective criteria ● Future use of a Juvenile Production Estimate as a tool for scaling loss triggers to population size
Delta	Winter and Spring Operations	Juvenile rearing and out-migration	Spring Delta Outflow ● Potential to use this action to reduce entrainment risk	Spring Delta Outflow Action and governance through technical and policy teams to schedule volumes
Delta	Winter and Spring Operations	Juvenile rearing and out-migration	Agricultural Barrier Operations ● Passage impediments increase exposure to predation in May and June	Technical and policy team coordination

Table 147. Southern Distinct Population Segment of green sturgeon summary of primary affected life stages, primary stressors/effect pathways, and relevant management actions for seasonal operations periods. These are the elements that will be incorporated into the Integration and Synthesis section of the opinion.

Division/Water body	Seasonal Operations Period	Affected Life Stage	Summary of Primary Stressors and Effects of the Proposed Action	Relevant Management Actions
Delta	Summer and Fall Operations	Juvenile rearing and migration	Delta Cross Channel Operations ● Minimal impacts on survival rates. Individuals have extended rearing periods in the Delta (months to years)	Delta Cross Channel Closures, technical and policy team coordination during real-time operations, and adaptive management

Division/Water body	Seasonal Operations Period	Affected Life Stage	Summary of Primary Stressors and Effects of the Proposed Action	Relevant Management Actions
Delta	Winter and Spring Operations	Adult migration	Delta Cross Channel Gate Closures ● Gate closures could impair upstream migration and cause migration delays	Delta Cross Channel Closures, technical and policy team coordination during real-time operations, and adaptive management
Delta	Winter and Spring Operations	Juvenile rearing and out-migration	Salvage and loss at state and federal export facilities ● Infrequent salvage of individuals	OMR (Old and Middle rivers) Flow Management, technical and policy team coordination during real-time operations, and adaptive management
Delta	Winter and Spring Operations	Juvenile rearing and out-migration	Agricultural Barrier Operations ● Passage impediments increase exposure to predation in May and June	Technical and policy team coordination

7.5.2. Effects of the Action on Critical Habitat in the Bay-Delta Division

Critical habitat impacted by the proposed action includes the waters of the Sacramento-San Joaquin Delta, generally defined as the legal Delta, which includes the region of waterways bounded by the Sacramento River downstream from the I Street Bridge in Sacramento, the San Joaquin River downstream from the Airport Way Bridge near Vernalis, waters bounded on the east approximately by the alignment of Interstate 5, and westwards to nearly the western tip of Chipps Island. This region provides three general habitat types essential to one or more life stages of listed fish, including freshwater rearing sites, freshwater migration corridors, and estuarine areas for rearing and migration. Designated critical habitat exists in the Bay-Delta Division for the following species:

- SR winter-run Chinook salmon
- CV spring-run Chinook salmon
- CCV steelhead
- sDPS green sturgeon

7.5.2.1. Effects to Salmonid Designated Critical Habitat

Critical habitat for SR winter-run Chinook salmon exists in the mainstem Sacramento River from the I Street Bridge in Sacramento to Chipps Island but also includes the waterways surrounding Kimball Island, Winter Island, and Browns Island within the Lower San Joaquin River, which are all contained within the western region of the legal Delta. Designated SR winter-run Chinook salmon critical habitat also includes the waters westward of Chipps Island to the Carquinez Bridge, including Suisun Bay, Honker Bay, Grizzly Bay, and the Carquinez Strait, San Pablo

Bay, and that portion of San Francisco Bay north of the Bay Bridge and extending to the Golden Gate Bridge. The critical habitat designation in the bays for SR winter-run Chinook salmon does not include any estuarine sloughs in this region.

Designated critical habitat for CV spring-run Chinook salmon exists in the northern Delta but not the San Joaquin River side of the Delta. Waterways include the mainstem Sacramento River from the I Street Bridge to the western tip of Sherman Island and the waterways located to the north of the mainstem Sacramento River, including Sutter, Steamboat, Miner, Elk, and Elkhorn sloughs, the Cache Slough complex, and the Yolo Bypass. Waterways to the south of the mainstem Sacramento River that are designated as CV spring-run Chinook salmon critical habitat include Georgiana Slough to its confluence with the Mokelumne River, Threemile Slough to its confluence with the San Joaquin River, and the portion of the Delta Cross Channel between the Sacramento River and Snodgrass Slough. Designated critical habitat for CCV steelhead includes most of the legal Delta, with a few exceptions.

Critical habitat for both CV spring-run Chinook salmon and CCV steelhead was designated concurrently, and as such, they share the same PBFs. The PBFs for SR winter-run Chinook salmon are related and similar to the habitat types of the other listed salmonids, but they were described with more specificity at the time of their designation. The general habitat types that occur within the Bay-Delta action area provide the structure for the assessment of habitat impacts for all salmonids. For each habitat type and each fish species, the specific PBFs that correspond to ESA-listed critical habitat are identified.

The PBFs of critical habitat in the Bay-Delta region include freshwater rearing areas, freshwater migration corridors, and estuarine areas used for rearing and migration. This analysis on the effects of the proposed action on critical habitat is based on information presented in preceding sections regarding its effects on listed salmonids, and the effects are summarized below as they relate to the PBFs of critical habitat.

7.5.2.1.1. Freshwater Rearing Habitat

Sacramento River winter-run Chinook salmon PBFs include:

- Habitat areas and adequate prey that are not contaminated
- Riparian habitat that provides for successful juvenile development and survival

Central Valley spring-run Chinook salmon and CCV steelhead PBFs include:

- Freshwater rearing sites with water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; water quality and forage supporting juvenile development; and natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks

Freshwater rearing habitat occurs for all three salmonid species in the main stem of the Sacramento River and the numerous waterways and sloughs comprising the northern Delta. Freshwater rearing habitat occurs in the South Delta waterways for only CCV steelhead. However, the quality of this rearing habitat in the Delta is variable, with most of it degraded by anthropogenic actions (i.e., levee construction, removal of riparian vegetation, and armoring of shorelines and levees) as described in the Environmental Baseline section.

Elements of the proposed action that would affect critical habitat include the operation of the seasonal South Delta agricultural barriers, which have the potential to degrade water quality by creating impoundments in tidally influenced riverine sections of the South Delta during the period of their installation (approximately May–November). This can reduce dissolved oxygen through less mixing, create warmer water temperature conditions due to a reduction in water exchange, and increase residence times for water upstream of the barriers. Due to the warmer temperatures and reduced flows, nonnative invasive plants and fish are favored. The change in habitat characteristics favors non-native predators such as centrarchids, as well as aquatic plants such as Brazilian waterweed and water hyacinth (*Eichhornia crassipes*). Such conditions reduce the value of the rearing habitat in the affected waterways for listed CCV steelhead migrating through these waterways when the barriers are in place. Construction of the South Delta agricultural barriers does not impact designated critical habitat in other portions of the South Delta or North Delta.

Conversely, the period of water transfers, July through November, may enhance rearing conditions in the northern Delta by increasing flows and improving water quality. Increased flows during this period may improve water temperatures, as well as increase dissolved oxygen through better mixing of the water column. Both of these effects will improve rearing habitats for listed salmonids. In addition, increased flows in the mainstem rivers may also benefit primary and secondary production, which then enhances the forage base for listed salmonids. However, under the proposed action element of water transfers, the level of exports is increased to capture this transfer water volume, and increased exports create conditions that diminish the value of the regional waterways as migratory corridors (see following discussion).

7.5.2.1.2. Freshwater Migratory Corridors

Sacramento River winter-run Chinook salmon PBFs include:

- Adequate river flows for successful downstream transport of juveniles
- Access from the Pacific Ocean to appropriate spawning areas in the Upper Sacramento River
- Access downstream so that juveniles can migrate from the spawning grounds to San Francisco Bay and the Pacific Ocean

Central Valley spring-run Chinook salmon and CCV steelhead PBFs include:

- Freshwater migration corridors free of obstruction and excessive predation with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival

Freshwater migratory corridor critical habitat occurs for all three salmonid species in the mainstem of the Sacramento River and the numerous waterways and sloughs comprising the northern Delta. Freshwater migratory corridor critical habitat occurs in the South Delta waterways for only CCV steelhead. The quality of this migratory habitat is variable, and some routes have substantially lower survival rates than other routes. The proposed action has several elements that will route migrating juvenile listed salmonids into migratory paths that have lower survival rates, or delay or alter migratory behavior, which affects transit times.

Within the North Delta, juvenile survival is higher along migratory routes within the main stem of the Sacramento River and, generally, the migratory routes that go through Sutter and

Steamboat sloughs. The proposed action has the potential to operate the Delta Cross Channel gates by closing the gates during the fall and early winter only as needed, through real-time operations coordinated with Delta Monitoring Teams and according to species presence determined by the Knights Landing or the Sacramento monitoring catch indices. Delta Cross Channel openings during December and January will occur only during drought conditions when there are water quality concerns that could be addressed by opening the Delta Cross Channel gates (see the Delta Cross Channel Gate [and Maintenance and Repair] section). When the Delta Cross Channel gates are open, the channel allows for the routing of juvenile listed salmonids into the interior Delta, where survival has been observed to be lower for acoustic-tagged Chinook salmon. Hydrodynamic modeling and studies using acoustic-tagged Chinook salmon have also shown downstream effects when the gates are open that increase the vulnerability of fish to routing into the interior Delta or delays in their migrations in the downstream reaches due to interactions with tidal flows within the river channels. Adults may also be affected by more frequent openings of the Delta Cross Channel gates through false attraction flows. Adult salmonids that are attracted into the Mokelumne River system by Sacramento River water flowing through the open Delta Cross Channel gates may become trapped behind the gates when they close. Upstream migration past the Delta Cross Channel will be delayed until these fish drop back down into the Lower Mokelumne River and pass upstream through an alternate route (i.e., Georgiana Slough) to the mainstem Sacramento River. To reduce the potential migration delay caused by adult routing into the Delta Cross Channel, Reclamation has proposed an additional closure of the Delta Cross Channel gate (October 1–November 30) when East Bay Municipal Utility District releases Lower Mokelumne River attraction flows.

Alterations in flow and the creation of migratory barriers are anticipated from the operation of the South Delta agricultural barriers for both adult and juvenile CV spring-run Chinook salmon and CCV steelhead. Acoustic-tagged juvenile steelhead and Chinook salmon were shown to be delayed in passing downstream over the weir crests of the barriers or through the tidally operated culverts penetrating the barriers. Fish milled above the locations of the barriers where reduction in survival was hypothesized to be related to greater exposure to predators upstream of the barriers. The relative increase in localized predation will impact the function of the freshwater migratory corridors of the designated critical habitat for CCV steelhead in the South Delta. Delays in upstream migration of adult CCV steelhead are also expected as the barriers will create impediments to the movement of fish through the affected channels. Passage over the weirs, even with the required notches and removal of flashboards in the fall, will be related to the depth of water passing over the weir crest. Water depth is greatest during the top of the flood tide and just after it turns to the ebbing tide following slack tide. Thus, passage is limited to only those periods of time when sufficient water depth over the weirs exists.

Water exports in the South Delta at the state and federal export facilities are expected to exert some influence on Delta hydrology, in turn affecting the downstream access and transport of juvenile salmonids. Although the ebb and flow of the tides predominate, obscuring some of the effect, there is a net degradation of Delta hydrology caused by operations of the export facilities and OMR Flow Management. The spatial extent of that degradation is related to the volume of exports and the relative Delta inflow from the Sacramento and San Joaquin rivers. Reclamation's analysis of the spatial extent of the influence of exports under CVP and SWP diversions uses the DSM2-HYDRO modeling. Detailed results are provided in "Appendix I_Attachment X - Delta Export OMR Zone of Influence Analysis.pdf" of the BA (U.S. Bureau of Reclamation 2023-

2024), which show that across all alternatives, most of the Delta (DSM2 nodes) experienced low hydrologic influence. The spatial extent (sum and proportion of channel length) of alteration under the proposed action ranges from 45,576 feet (1.2 percent of the DSM2 grid in Alt2v2) to 559,302 feet (14.7 percent of the DSM2 grid in Alt2v1). The greatest extent of hydrologic alteration occurs in the more negative than -5500 OMR bin, which is likely associated with greater exports.

Some aspects of the proposed action may improve migratory corridor function, namely the timing and operations associated with the movement of water during the water transfer window. Since transfers may originate from either the Sacramento or San Joaquin river basins, designated critical habitat for all three listed salmonid species may be affected (see above description of the locations of designated critical habitat within the Delta region). As discussed above, increased flows associated with the releases of transfer water will enhance the riverine portions of the Delta by increasing flow velocity within the main channels. This should reduce the necessary transit time for any juvenile listed salmonids required to move through a given reach of the river. The benefits to migratory corridors will be related to the volume and duration of any water transfers. More volume or prolonged duration of water releases are believed to provide better migratory conditions than shorter or smaller volumes of releases. Increased flows with concurrent increases in water velocity and reductions in transit time will reduce the exposure of juvenile listed salmonids to predators and should, therefore, reduce predation and increase survival. For adult salmonids moving upstream (predominantly CCV steelhead due to the timing of the transfer window), increased flows should stimulate upstream migration into the upper rivers from the Delta and provide better olfactory cues to upstream regions. However, while the increased flows due to water transfers will benefit listed salmonids, the concurrent export of this water will create the altered hydrodynamics discussed previously. This offsetting effect will be greatest for the designated CCV steelhead critical habitat in the San Joaquin River side of the Delta.

7.5.2.1.3. Estuarine Habitat for Rearing and Migration

Sacramento River winter-run Chinook salmon PBFs include:

- Habitat areas and adequate prey that are not contaminated
- Riparian habitat that provides for successful juvenile development and survival
- Access from the Pacific Ocean to appropriate spawning areas in the Upper Sacramento River
- Access downstream so that juveniles can migrate from the spawning grounds to San Francisco Bay and the Pacific Ocean

Central Valley spring-run Chinook salmon and CCV steelhead PBFs include:

- Estuarine areas free of obstruction and excessive predation with water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh- and saltwater; natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels; and juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation

Estuaries are the zones in which freshwater from upstream riverine sources mixes with the full salinity of marine water. An estuary is a partially enclosed body of water, and its surrounding

coastal habitats, where saltwater from the ocean mixes with freshwater from rivers or streams. In freshwater, the concentration of salts, or salinity, is nearly zero. The salinity of water in the ocean averages about 35 ppt. The mixture of seawater and freshwater in estuaries is called brackish water, and its salinity can range from 0.5 to 35 ppt. A salinity (in ppt) of 0.5 is approximately equivalent to 1,000 microsiemens conductivity at 22°C. Those waters of the Delta upstream of Rio Vista on the Sacramento River and Jersey Point on the San Joaquin River would typically have salinities of 0.5 ppt or lower based on the measured conductivity at almost all times. River inflow and tides will influence where the boundary of 0.5 ppt salinity will be found. Thus, the estuarine regions of the Delta would include designated critical habitat for SR winter-run Chinook salmon, CV spring-run Chinook salmon, and CCV steelhead downstream from Rio Vista to the junction of the Sacramento and San Joaquin rivers. Estuarine critical habitat for CCV steelhead would extend from approximately Jersey Point downstream to Chipps Island on the San Joaquin River side of the Delta. Critical habitat for SR winter-run Chinook salmon and CCV steelhead would also include the western portions of the Delta and the waterways from Chipps Island to the Golden Gate Bridge, as described previously.

Within the Bay-Delta region, the proposed action will affect the PBFs of critical habitat in a number of ways. Increased river inflows due to upstream reservoir releases can move the extent of salinity intrusion farther to the west, theoretically increasing the area of productive mixing in the western Delta between fresh and saline waters. This will lead to increasing amounts of primary and secondary productivity, which, in turn, enhances the forage base for juvenile salmonids. The PBFs for SR winter-run Chinook salmon include "habitat areas and adequate prey that are not contaminated." Likewise, the PBFs for CV spring-run Chinook salmon and CCV steelhead include a provision for "juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation." The increase in primary and secondary productivity associated with a mixing zone in the western portion of the Delta will provide these PBFs.

Listed SR winter-run Chinook salmon, CV spring-run Chinook salmon, and CCV steelhead could be affected by the operation of the SMSCG, with the gates potentially delaying upstream-migrating adults that have entered Montezuma Slough and are seeking to exit the slough at its eastward end. Adult SR winter-run Chinook salmon, CV spring-run Chinook salmon, and CCV steelhead that do not continue upstream past the SMSCG through the open boat lock gates are expected to return downstream by backtracking through Montezuma Slough to Suisun Bay, and they will likely find the alternative upstream route to their natal Central Valley streams through Suisun and Honker bays. The tidally-operated gates are also expected to influence water currents and tidal circulation periodically during the 10 to 80 days of annual operation, which could also delay juvenile SR winter-run Chinook salmon, CV spring-run Chinook salmon, and CCV steelhead migration. However, most of these operations are expected during the summer when listed fish are less likely to be present and where changes in water flow will be limited to the flood portion of the tidal cycle for a few days during each operational episode. Overall, the short-term changes to tidal flow patterns in Montezuma Slough due to the operation of the SMSCG are expected to cause a minor impact to this PBF for both migrating juveniles and adults of these listed salmonids. The operations of the SMSCG may impact designated critical habitat estuarine PBFs for CCV steelhead or CV spring-run Chinook salmon migration due to the gates being located in waters, which although not specifically identified as critical habitat for these species, do lie within the area of San Francisco-San Pablo-Suisun Bay as defined by the perimeter of the

water body as displayed on a 1:24,000 scale topographic map or by the extreme high water mark, whichever is greater. Proposed operations of the SMSCG during the summer months (June–September) for up to 60 days in below normal and above normal water years (Sacramento Valley Index) to improve habitat for Delta smelt in the Suisun Marsh waterways will not impact critical habitat for SR winter-run Chinook salmon as any changes to the habitat are not permanent and it is not expected that any adult or juvenile SR winter-run Chinook salmon will be present during this time period to be exposed to the gate operations. In contrast, some adult CCV steelhead may be affected as they migrate upriver during the summer and early fall. Adult CV spring-run Chinook salmon are unlikely to be affected during the summer gate operations.

7.5.2.1.4. Summary of Effects to Salmonid Designated Critical Habitat

A summary of effects to salmonid critical habitat in the Delta is provided in

Table 148.

Table 148. Summary of affected physical or biological features of Central Valley salmonids designated critical habitat in the Delta.

Action Component	Physical or Biological Feature Affected	Species	Response
Water transfers	Freshwater rearing sites	SR WRCS, CV SRCS, CCV SH	(1) In-river flows that provide suitable water temperature conditions in the mainstem Sacramento River. (2) Flows that provide suitable dissolved oxygen conditions through improved mixing of water column and water surface-air interface. (3) Water quality sufficient to support primary and secondary productivity, benefitting forage base. (4) Insufficient conditions for successful holding and rearing habitat for juveniles in the south Delta due to water transfers resulting in increased exports.
Water transfers	Freshwater migratory corridor	SR WRCS, CV SRCS, CCV SH	Enhanced flows from water transfers can benefit migratory habitat for juvenile listed salmonids migrating downstream by decreasing travel times, increasing the length of riverine reaches, and muting downstream tidal effects. Increased flows can also stimulate upstream migration of CCV SH in the fall. Contribution of water transfers to increased exports may degrade migratory habitat in the South Delta.
North Bay Aqueduct/Barker Slough Pumping Plant	Freshwater migratory corridor	SR WRCS, CV SRCS, CCV SH	Operations of North Bay Aqueduct/Barker Slough Pumping Plant may alter flow patterns affecting the migratory corridor PBF thereby inhibiting the mobility of juvenile listed salmonids and reducing their survival.

Action Component	Physical or Biological Feature Affected	Species	Response
Delta Cross Channel Gate Closures (and Maintenance and Repair)	Freshwater migratory corridor	SR WRCS, CV SRCS, CCV SH	(1) Access to the interior Delta through open Delta Cross Channel gates reduces the survival of migrating juveniles, reducing the value of the mainstem as a suitable migratory corridor. (2) Operations of the Delta Cross Channel gates can alter the extent of tidal influence in the river reaches downstream of the Delta Cross Channel location, delaying migration or re-routing juveniles into alternate migratory routes with lower survival. (3) Operations of the Delta Cross Channel gates reduces the upstream migratory function of the mainstem Sacramento River to adults, enhances straying and migratory delays. (4) Open Delta Cross Channel gates allow access to habitat under the influence of the SWP and CVP export actions.
CVP and SWP Export Facilities, and Old and Middle River Flow Management	Freshwater migratory corridor	CCV SH	Increased exports by the CVP and SWP export facilities create hydrodynamic conditions in the channels of the South Delta that impede CCV steelhead migration downstream to the ocean (reverse flows).
South Delta Agricultural Barriers	Freshwater rearing sites	CCV SH	Operation of the South Delta agricultural barriers will reduce flow velocities and increase water residence time within channels of the South Delta, degrading water quality and potentially increasing water temperatures.
South Delta Agricultural Barriers	Freshwater migratory corridor	CCV SH	Operation of the South Delta agricultural barriers create (1) physical barriers within the migratory corridor PBF; (2) decreases in water quality, including lower dissolved oxygen and suitable water temperatures that impair fish physiology; and (3) habitat with excessive predation risk.
Delta Smelt Summer and Fall Habitat	Freshwater rearing sites	SR WRCS, CV SRCS, CCV SH	Release of additional water from upstream to augment Delta outflow will improve water quality and enhance forage prey populations that support juvenile salmonid development.
Delta Smelt Summer and Fall Habitat	Freshwater migratory corridor	SR WRCS, CV SRCS, CCV SH	Release of additional water from upstream to augment Delta outflow will improve water quality and conditions supporting the mobility and survival of adult and juvenile salmonids
Delta Smelt Summer and Fall Habitat	Estuarine areas	SR WRCS, CV SRCS, CCV SH	Release of upstream water will (1) enhance water quality, water quantity, and provide suitable salinity conditions supporting juvenile and adult salmonid physiological transitions; and (2) enhance forage prey that will support growth and maturation. Operations of the Suisun Marsh Salinity Control Gates will create temporary obstructions to free migration and potentially create predator habitat.

SR WRCS = Sacramento River winter-run Chinook salmon; CV SRCS = Central Valley spring-run Chinook salmon; CCV SH = California Central Valley steelhead.

7.5.2.2. Effects to Green Sturgeon Designated Critical Habitat

Members of the sDPS green sturgeon population utilize the aquatic habitat of the Delta for rearing, resting, holding, foraging, and migration. Critical habitat has been designated to include all of the waters of the legal Delta with a few exceptions and the waters of Suisun Bay, San Pablo Bay, and north and south San Francisco bays up to the highest high tide line.

7.5.2.2.1. Freshwater Riverine Systems

The following PBFs apply to the designated critical habitat for the sDPS of green sturgeon in freshwater riverine systems of the Delta:

- Food resources
- Substrate type or size
- Water Flow
- Water quality
- Migratory corridor
- Water Depth
- Sediment quality

As described previously for listed salmonids, actions related to the proposed action include the operation of the seasonal South Delta agricultural barriers, which have the potential to degrade water quality by creating impoundments in tidally influenced riverine sections of the South Delta during the period of their installation (approximately May–November). The barriers also create impediments to migratory corridors through the channels of the South Delta, including primarily Old River and Grant Line Canal. Middle River is also blocked by the agricultural barriers, but the water depth and habitat present are unlikely to be suitable for sDPS green sturgeon even when the barrier is absent. When the barriers are constructed, they begin to slow the flow of water through the impacted channels and reduce velocities and turnover of the water mass. This leads to increasing thermal load for the impounded waters due to warm air temperatures and solar irradiation. As a result of this, water quality tends to decline, particularly dissolved oxygen levels. Low dissolved oxygen coupled with increasing water temperatures create inhospitable habitat conditions for sDPS green sturgeon. However, the overall impact to sDPS green sturgeon critical habitat is considered to be low due to the low proportion of the sDPS green sturgeon population found in the waterways of the South Delta.

Operations of the Delta Cross Channel gates in the North Delta can lead to potentially adverse migratory corridor conditions for juvenile and adult sDPS green sturgeon. However, very little is known regarding the utilization of different habitat types by either adult or juvenile sDPS green sturgeon in the Delta. Since juvenile sDPS green sturgeon spend several months to years rearing in the Delta, diversion into the Delta interior may not adversely impact the survival of individual fish. These waters are accessible to juvenile sDPS green sturgeon from the San Joaquin River via the channels of the Mokelumne River system and may not materially increase migratory transit time or distance during their prolonged rearing phase. Without information regarding habitat use and preferences and survival of juvenile sDPS green sturgeon through the interior Delta routes,

there is insufficient information to conclude that this alternative route is worse than remaining in the mainstem of the Sacramento River. Adults migrating downstream after spawning may pass through the Delta Cross Channel, but migration through the Mokelumne River system and into the Lower San Joaquin River and then to the western Delta via the mainstem of that river may not adversely affect these individual fish. For adult sDPS green sturgeon migrating upstream to spawn, open Delta Cross Channel gates may provide a false attraction cue to the Sacramento River basin via the San Joaquin River and Mokelumne River systems. Fish may be delayed if gates are subsequently closed, forcing them to backtrack to regain access to the Sacramento River. It is not known whether this would create an adverse effect to the spawning ability and success of impacted fish. The impact of the Delta Cross Channel gate operations on sDPS green sturgeon critical habitat is considered to be low. Given the extended period of time that juvenile and adult sDPS green sturgeon may spend in the Delta region before migrating to the marine environment, the changes in migratory routing and transit times may not materially impact the functioning of the Sacramento River as a migratory route.

Operations of the North Bay Aqueduct/Barker Slough Pumping Plant and the Contra Costa Water District/Rock Slough diversion may create temporary delays in migration through the diversion of water from the dead-end sloughs they are located on. There is the potential that individual fish in waterways adjacent to the facilities may experience temporary interruptions in their movements due to the slight reverse flow towards the export location caused by the diversion of water. As explained in the previous paragraph, juvenile and adult sDPS green sturgeon may spend extended periods of time in the Delta, and the impact of a short-term delay is unknown. The magnitude of the effects on the functioning of the critical habitat as a migratory corridor is therefore considered to be low from the operations of these two export facilities.

In contrast, the effects of the SWP and CVP exports in the South Delta are much larger. The volume of water exported is substantially greater than that which is exported by the Contra Costa Water District and Barker Slough Pumping Plant operations. Flows in the South Delta waterways that are part of the designated critical habitat for sDPS green sturgeon are typically altered to the point that net flows move upriver towards the export facilities from downstream locations (reverse flows). The extent of the footprint of these export effects is variable. In dry conditions, with little inflow to the Delta from the Sacramento and San Joaquin river basins, the effects of the SWP and CVP diversions can extend a considerable distance and may impact waterways as far downstream on the San Joaquin River as Jersey Point through the combined effects of tidal forcing and net reverse flows. In wetter conditions, with substantially higher inflows to the Delta, this impact is muted, particularly if the San Joaquin River has high flows. Under reverse water flow, fish migration is not only delayed, but individual fish may be more likely to be entrained into the export facilities. At the CVP, small fish may enter the fish salvage process, while larger fish are screened out of the facilities by the trash rack. At the SWP, both adult and juvenile fish are entrained into the CCF when the radial gates are open and may be detained in this waterbody for a considerable amount of time. Smaller fish may be salvaged at the Skinner Delta Fish Protective Facility, as they can pass through the trash racks, while larger fish are prevented from entering the salvage process due to the narrow spacing of the metal bars on the trash rack screen. Larger fish can only escape the CCF if they swim back out of the radial gates and reenter the Delta via West Canal and Old River. Although the physical effects related to the operations of the SWP and CVP are large, the impacts to the migratory corridor element of the PBFs is considered medium due to the distribution of sDPS green sturgeon in the Delta. Furthermore, the

proposed action has south Delta export facility loss thresholds for listed salmonids that, when triggered, have the potential to reduce exports if exceeded, thereby reducing the potential magnitude of hydrodynamic effects in channels leading to the export facilities when implemented.

There are several elements of the proposed action that occur within the SWP and CVP facilities or CCF that could affect sDPS green sturgeon directly or the aquatic habitat they are found in. However, these areas are outside the limits of designated critical habitat for sDPS green sturgeon and will not be discussed further.

7.5.2.2.2. Estuarine Systems

The following PBFs apply to the designated critical habitat for sDPS green sturgeon in estuarine systems of the Delta:

- Food resources
- Substrate type or size
- Water Flow
- Water quality
- Migratory corridor
- Water Depth
- Sediment quality

The same definition of estuarine areas that applied to listed salmonids will be used for sDPS green sturgeon. Estuarine areas are those waters with salinities ranging from 0.5 ppt to full seawater salinity (35 ppt). Those waters of the Delta upstream of Rio Vista on the Sacramento River and Jersey Point on the San Joaquin River would typically have salinities of 0.5 ppt or lower based on the measured conductivity at almost all times. River inflow and tides will influence where the boundary of 0.5 ppt salinity will be found. The estuarine regions of the Delta would include those portions of the Delta downstream of approximately Rio Vista on the Sacramento River and Jersey Point on the San Joaquin River and all waters to the west, including Suisun Bay, Honker Bay, Grizzly Bay, Suisun Marsh, San Pablo Bay, north and south San Francisco Bay, and all tidally influenced sloughs and channels up to the mean higher high tide line in those bodies of water.

Few actions described for the proposed action will impact estuarine critical habitat PBFs for sDPS green sturgeon. Increased outflow from reservoirs will benefit sDPS green sturgeon by increasing the area of high productivity created by moving the mixing zone farther to the west into the western Delta and Suisun Bay. However, since sDPS green sturgeon are capable of tolerating a wide variety of salinities as either juveniles, sub-adults, or adults and foraging on a wide variety of food sources, including most benthic invertebrates and several species of fish found in the Delta and estuarine areas, they are not limited to the area of increased mixing for foraging. Higher flows would enhance upstream spawning migrations for adults in the winter and spring, allowing fish to orient to the flow cues. However, flows should be sufficient to allow this behavior under the proposed action in most circumstances.

Listed sDPS green sturgeon could be affected by the operation of the SMSCG, with the gates potentially delaying upstream-migrating adult sDPS green sturgeon that have entered the Montezuma Slough migratory route and are seeking to exit the slough at its eastward end. Adult sDPS green sturgeon that do not continue upstream past the SMSCG through the open boat lock

gates are expected to return downstream by backtracking through Montezuma Slough to Suisun Bay, and they will likely find the alternative upstream route to their natal Central Valley streams through Suisun and Honker bays. Post-spawn adult sDPS green sturgeon migrating downstream may have their entrance into Montezuma Slough blocked or impeded by SMSCG operations. However, any fish that is blocked or impeded from using this route can easily access Suisun Bay through the mainstem Sacramento River, thus, little, if any, adverse effects to migratory routing are anticipated.

The impacts to estuarine critical habitat for sDPS green sturgeon related to the restoration of 5,677 acres of tidal habitat will be the same as already described for listed salmonids. It is anticipated that there will be temporary adverse impacts to the functioning of estuarine critical habitat related to the degradation of water quality, release of contaminants, and reduction in local forage food resources during construction. Long-term benefits will include an increase in the production of food resources associated with tidal habitat and marshes and the improvement in water quality conditions due to the functioning of the tidal habitat and any associated fringing marshes to remove contaminants from the system.

7.5.2.2.3. Summary of Effects to the Southern Distinct Population Segment of Green Sturgeon Critical Habitat

A summary of effects to sDPS green sturgeon critical habitat in the Delta is provided in Table 149.

Table 149. Summary of affected physical or biological features of the Southern Distinct Population Segment of green sturgeon designated critical habitat in the Delta.

Action Component	Physical or Biological Feature Affected	Response
Water transfers	Freshwater Riverine Habitat	(1) Additional in-river flow may improve water quality conditions (i.e., temperatures and dissolved oxygen) in the mainstem Sacramento River. (2) Improved water flow may improve migratory corridor conditions. (3) Improved water quality in fall may improve primary and secondary productivity, benefitting food resources.
North Bay Aqueduct/Barker Slough Pumping Plant	Freshwater Riverine Habitat	Operations of North Bay Aqueduct/Barker Slough Pumping Plant may delay movements of juveniles due to alterations to flow patterns created by the export of water and thereby impeding the mobility of juvenile green sturgeon.

Action Component	Physical or Biological Feature Affected	Response
Delta Cross Channel Gate Closures (and Maintenance and Repair)	Freshwater Riverine Habitat	(1) Access to the interior Delta through open Delta Cross Channel gates alters the function of the mainstem Sacramento River as a suitable migratory corridor to the western Delta. (2) Operations of the Delta Cross Channel gates can alter the extent of tidal influence in the river reaches downstream of the Delta Cross Channel location, delaying migration or re-routing juveniles into alternate migratory routes with lower habitat quality. (3) Operations of the Delta Cross Channel gates reduces the upstream migratory function of the mainstem Sacramento River to adults, enhancing straying and migratory delays. (4) Open Delta Cross Channel gates allow access to habitat under the influence of the SWP and CVP export actions.
CVP and SWP Export Facilities, and Old and Middle River Flow Management	Freshwater Riverine Habitat	Increased exports by the CVP and SWP export facilities create hydrodynamic conditions in the channels of the South Delta that impede or alter green sturgeon movements in the region's migratory corridors (reverse flows).
South Delta Agricultural Barriers	Freshwater Riverine Habitat	Operations of the South Delta agricultural barriers will reduce flow velocities and increase water residence time within channels of the South Delta, degrading water quality and potentially increasing water temperatures. Construction of the South Delta agricultural barriers creates barriers to the movements of adult and juvenile green sturgeon within the South Delta waterways containing the barriers.
Delta Smelt Summer and Fall Habitat	Freshwater Riverine Habitat	Releases of additional water from upstream to augment Delta outflow will improve water quality and enhance forage prey populations that support juvenile and adult green sturgeon. Releases of additional water from upstream to augment Delta outflow will improve water flow supporting the mobility and survival of adult and juvenile green sturgeon.
Delta Smelt Summer and Fall Habitat	Estuarine areas	Release of upstream water will (1) enhance water quality and water quantity, and (2) enhance juvenile and adult forage prey that will support growth and maturation. Operations of the Suisun Marsh Salinity Control Gates will create temporary obstructions to free migration.

7.6. Southern Resident Killer Whale

7.6.1. Effects of the Action on Southern Resident Killer Whales

The potential impact of the proposed action on SRKWs is the change in availability of SRKW preferred prey, Chinook salmon, in the coastal waters where SRKWs may encounter Chinook salmon from the Central Valley of California.

In terms of productivity and abundance, the vast majority of CV Chinook salmon are non-ESA-listed fall-run Chinook salmon and, to a lesser degree, non-ESA-listed late fall-run Chinook salmon and ESA-listed populations of CV spring-run Chinook salmon, and least of all ESA-listed SR winter-run Chinook salmon. Estimates provided by the Pacific Fishery Management

Council (PFMC) of annual ocean abundance for the Sacramento and San Joaquin rivers and their associated tributaries indicate that fall-run Chinook salmon abundance is typically on the order of several hundred thousand adults, compared to tens of thousands each for late fall-run and CV spring-run Chinook salmon, and several thousand adults for SR winter-run Chinook salmon (Pacific Fishery Management Council 2024a).

The potential impact of the proposed action on SRKWs occurs through impacts to the availability of all potential Chinook salmon prey sources from the Central Valley. Our approach to analyzing the effects of the proposed action on SRKWs included analysis of the impacts to fall-run and late fall-run Chinook salmon, and the impacts to ESA-listed SR winter-run and CV spring-run Chinook salmon, as individuals from all populations are potential prey for SRKWs along the West Coast of the United States. We did not conduct the same analysis for non-ESA-listed Chinook salmon during the consultation as we did for ESA-listed species because it is not what the ESA requires.

We will focus on the overall impact of the proposed action on Chinook salmon productivity from the entire system and the ultimate abundance of CV Chinook salmon in the ocean that may be available as prey for SRKWs using available information that characterizes the overall population-level effects of the proposed action. To do this, we consider the available quantitative and qualitative information that describes the underlying and ongoing effects of water operations on all Chinook salmon populations under the proposed action. Where possible, we explore this Chinook salmon population-level analysis quantitatively, drawing upon available models of sources of mortality related to the proposed action. Finally, where necessary, we consider additional qualitative assessment of stressors that cannot be captured directly through these models. See Appendix C of this opinion for a detailed description of quantitative analyses referenced in this section.

7.6.1.1. Project-Related Impacts on the Prey Base

To evaluate the effects of the proposed action on SRKWs, we examined the current trends in CV Chinook salmon abundance and the impacts of the proposed action on CV Chinook salmon populations.

7.6.1.1.1. Current Trends in Central Valley Chinook Salmon Abundance

The PFMC modeling represents the best estimates for the abundance of adult CV Chinook salmon in the ocean. These models are designed to inform fisheries management. Over the last 22 years (2001 to 2022), the total estimated pre-harvest ocean abundance of each run of CV Chinook salmon has varied considerably (Table 150; Figure 155); especially the total abundance for the predominant fall-run Chinook salmon, which has ranged from just under 45,000 adults to over 1,500,000 adults during that period (Table 150; Figure 156). The most recent year for which complete data are reported by the PFMC, 2022, showed a roughly 36-percent decline in abundance compared to the previous 10-year average (Pacific Fishery Management Council 2024a). Using analysis of variance (ANOVA) linear regression, trends indicate that the average total annual pre-harvest adult ocean abundance has significantly declined over the last 22 years for fall-run Chinook salmon (Figure 156; $F=12.55$; $\alpha=0.002$), late fall-run Chinook salmon (Figure 156; $F=13.58$; $\alpha=0.001$), and CV spring-run Chinook salmon (Figure 156, $F=3.19$; $\alpha=0.089$). The trend for SR winter-run Chinook salmon is also negative, but not significantly (Figure 156; $F=1.73$; $\alpha=0.204$).

Table 150. Annual Adult Central Valley (CV) Chinook salmon pre-harvest abundance, all rivers and runs combined.

Year	Fall[a]	Late fall[a]	Spring[a]	Winter[b]	Adult Ocean CV Chinook Salmon[c]
2001	1,122,059	31,411	38,395	8,923	1,200,788
2002	1,546,698	59,801	37,064	8,073	1,651,636
2003	1,250,163	13,945	48,194	8,917	1,321,218
2004	1,209,274	24,763	30,013	8,538	1,272,587
2005	988,567	25,888	36,718	17,185	1,068,359
2006	593,507	22,935	19,617	18,766	654,825
2007	262,368	31,091	18,388	2,757	314,603
2008	71,874	10,994	14,190	3,071	100,129
2009	44,792	10,298	4,490	4,923	64,503
2010	161,919	11,686	5,411	1,732	180,748
2011	239,266	11,996	11,042	897	263,201
2012	660,491	9,278	34,760	2,898	707,428
2013	901,549	13,776	36,429	6,603	958,358
2014	579,724	21,011	15,953	3,271	619,960
2015	289,367	14,586	7,742	3,732	315,427
2016	246,479	8,756	12,687	1,681	269,604
2017	190,160	8,138	2,673	1,062	202,033
2018	256,248	7,884	7,535	2,863	274,530
2019	538,918	19,191	33,998	8,819	600,925
2020	361,329	8,292	5,303	8,059	382,983
2021	341,449	6,512	47,440	11,445	406,845
2022	270,980	12,697	12,151	6,583	302,411
Average	**551,236**	**17,497**	**21,827**	**6,400**	**596,959**
Median	**351,389**	**13,236**	**17,171**	**5,753**	**394,914**
Standard Deviation	**432,217**	**12,114**	**14,946**	**4,853**	**454,430**

[a]Assumes same harvest rate for San Joaquin fall, late fall, and CV spring-run as Sacramento fall-run Chinook salmon

[b]Assumes 8.5% harvest rate for Sacramento River winter-run Chinook salmon based on Pacific Fishery Management Council management goals

[c]Pre-harvest, 3-year adult Chinook salmon

Source: calculated from data in (Pacific Fishery Management Council 2024a).

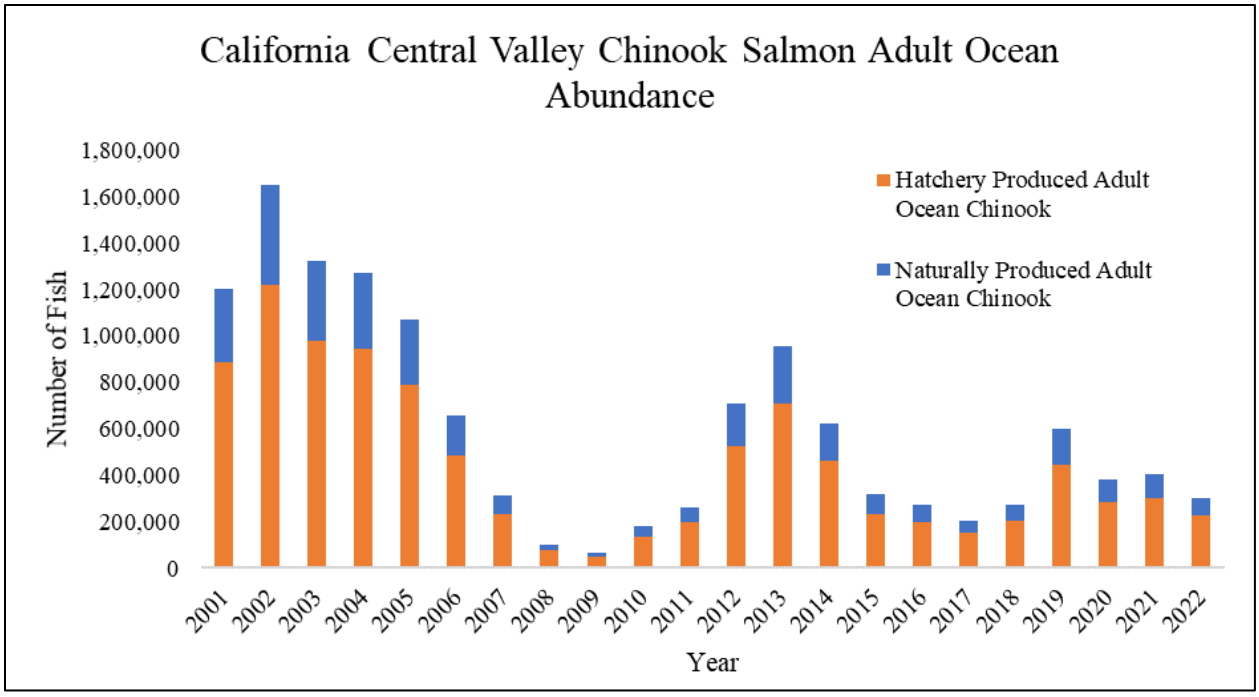


Figure 155. Ocean abundance for Central Valley Chinook salmon, all runs combined, from 2001 through 2022. Assumes a hatchery proportion of 0.74 calculated from coded wire tag recovery reports from years 2011-2022.

Source: (Pacific Fishery Management Council 2024a).

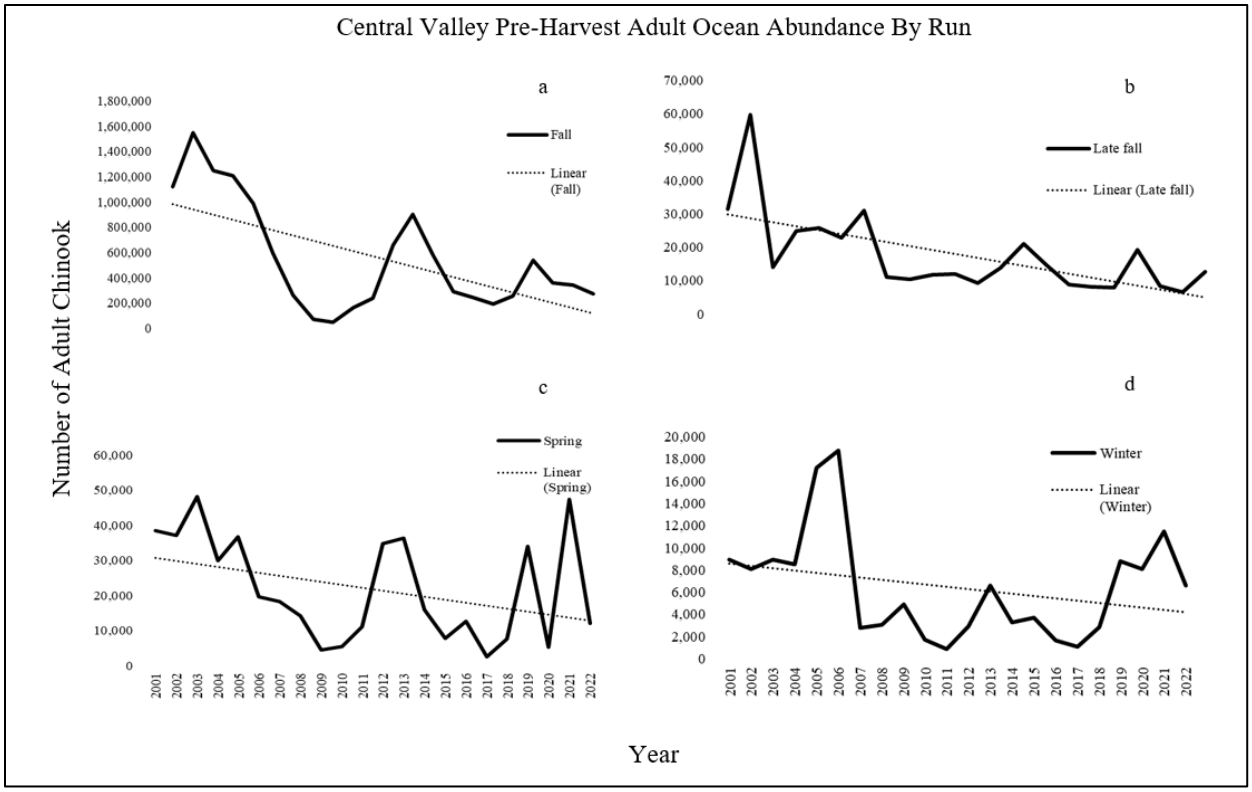


Figure 156. Pre-harvest ocean abundance of 3-year adult Central Valley (a) fall-run, (b) late fall-run, (c) Central Valley spring-run, and (d) Sacramento River winter-run Chinook salmon from 2001 through 2022.

Source: calculated from data provided by (Pacific Fishery Management Council 2024a).

There are likely many factors that contribute to the declining trends in abundance and productivity of CV Chinook salmon, including variation in natural and human-caused mortality and other influences on the quantity and quality of available habitat, survival, and ultimate reproductive success throughout their life cycle in both the freshwater and marine environment (Michel 2018). These include significant influences such as harvest, hatchery production, and habitat alterations (see Status of the Species and Environmental Baseline sections). Among other major influences for all Chinook salmon in the Central Valley is the ongoing operation of the CVP and SWP. The 2019 opinion analyzed effects of a number of proposed restoration actions or programs to improve salmon production, growth, and survival (National Marine Fisheries Service 2019b). Reclamation proposed to conduct habitat restoration projects in the Sacramento River, American River, and Stanislaus River through 2030. An estimated 15,273 additional Chinook salmon could be available as a result of these projects by 2030, assuming that habitats are otherwise at carrying capacity and that any new habitat translates directly into more fish (Appendix J of National Marine Fisheries Service 2019b). However, water operational factors are not figured into these estimates so they cannot be directly aggregated with estimated impacts to SRKW prey abundance. Restoration of 6,000 acres of tidal wetlands in the Delta is also expected to improve growth and survival of juvenile Chinook salmon prior to entering the ocean. While the specific level impact of restoration benefits that may be realized is uncertain, we anticipate that the increase in habitat should help to offset impacts to populations from water operational factors and improve conditions for naturally produced CV Chinook salmon.

7.6.1.1.2. Proposed Action Impacts to Central Valley Chinook Salmon

The effects analyses of this opinion for ESA-listed fish identified several proposed action components with stressors that have medium to high levels of severity, resulting in a medium to high magnitude effect for CV spring-run and SR winter-run Chinook salmon, as well as CCV steelhead. The greatest effects will occur during the drier water years when the effects of the proposed action are most pronounced. The adult migration timing of fall and late fall-run CV Chinook salmon is similar to CCV steelhead in the Sacramento River, although spawning for fall-run Chinook salmon is earlier (October through December). Therefore, we would generally expect that adult migration of non-ESA listed fall- and late fall-run CV Chinook salmon would be similarly impeded by warm water temperatures in the fall as described for CCV steelhead, and the earliest spawned redds potentially impacted as well, similar to temperature impacts described for incubating CV spring-run Chinook salmon. Fall- and late fall-run Chinook salmon redds would also be subject to dewatering (more so for fall-run Chinook salmon than late fall-run Chinook salmon) due to proposed flow reductions from peaks in the summer to minimum flows in the fall and winter. Juvenile out-migration timing of fall- and late fall-run Chinook salmon is also similar to that of CV spring-run Chinook salmon and CCV steelhead in the Sacramento River, such that impacts of habitat access, migration routing, and entrainment at export facilities for fall- and late fall-run Chinook salmon are expected to be similar to those described above for the ESA-listed species. These reductions would decrease the abundance of Chinook salmon populations in the ocean and the availability of these Chinook salmon populations as prey for SRKWs.

Measures would be taken specifically to limit effects to the listed CV spring-run and SR winter-run Chinook salmon under the proposed action. Pulse flows during the spring could improve conditions for rearing and migration along the Sacramento River, Clear Creek, and through the Delta. These measures are expected to mitigate some of the adverse impacts of the proposed action.

7.6.1.2. Hatchery Production

The production and release of hatchery Chinook salmon of different run types from various hatcheries represents a substantial proportion of overall Chinook salmon productivity in the Central Valley. Table 151 describes the general release goals for each Central Valley hatchery and run type, as well as the average proportions of releases made directly in-river and releases transported directly into San Francisco Bay based on production and release activity 2011–2020 (Palmer-Zwahlen and Kormos 2015, Palmer-Zwahlen et al. 2018, 2019, 2020, Letvin et al. 2021, Dean and Lindley 2023). The proportion of hatchery fish present in the ocean fishery data over the 11-year period ranged from 0.57 to 0.88, with an average value of 0.74 (Pacific Fishery Management Council 2024a). A separate analysis of Chinook salmon otoliths in 1999 and 2002 found that the contribution of hatchery-produced fish made up approximately 90 percent of the ocean fishery off the central California coast from Bodega Bay to Monterey Bay (Barnett-Johnson et al. 2007); however, the more recent average value of 0.74 from the Central Valley CWT data is used in this analysis. The proportion of hatchery fish released in-river and in San Francisco Bay varies year-to-year based on water year conditions and other factors.

Table 151. Central Valley Chinook salmon hatchery release goals and proportion released in-river and in Bay areas. The proportion of hatchery fish released in-river and in San Francisco Bay varies from year to year based on water year conditions and other factors.

Hatchery Chinook	Run	General Goal	Released in Bay	Released in River
Coleman NFH	Fall	12,000,000	0%	100%
Coleman NFH	Late Fall	1,000,000	0%	100%
Livingston Stone NFH	Winter	200,000	0%	100%
Feather	Fall	6,000,000	70%	30%
Feather	Spring	2,000,000	50%	50%
Feather Enhancement	Fall	2,000,000	100%	0%
Nimbus	Fall	4,000,000	33%	67%
Mokelumne	Fall	5,000,000	70%	30%
Mokelumne Enhancement	Fall	2,000,000	100%	0%
Merced	Fall	300,000	0%	100%
Totals		**34,500,000**	**41%**	**59%**

NFH = National Fish Hatchery

Numerous factors likely cause the large influence of hatchery fish on the productivity of CV Chinook salmon. These factors include decreased survival rates of natural production in the system, and hatchery release practices that have been modified over time to improve the survival of hatchery fish through the system (e.g., release of hatchery production directly into San Francisco Bay via trucks to avoid the Delta). Consequences of this influence of hatchery production on naturally produced Chinook salmon include increasing the number of returning adults that stray to non-natal watersheds, further diminishing the genetic integrity of those watersheds' natural populations, which likely weakens the viability of the natural stocks to persist.

In 2009, NMFS reviewed the effects of the proposed operations of the CVP and SWP and issued a biological opinion that concluded the effects resulted in an appreciable reduction in both the survival and recovery of SRKWs. NMFS developed an RPA in coordination with Reclamation and DWR (amended in 2011) that identified 72 actions, some of which would contribute to avoid jeopardizing the continued existence of the SRKWs (National Marine Fisheries Service 2009a).The 2009 Opinion quantified the effects of hatchery production and project operations on non-listed Chinook salmon available to SRKWs as prey and found that hatchery programs produce more Chinook salmon than are killed in project operations, but can have harmful effects on the long-term fitness of salmon populations in the Central Valley. To address current hatchery practices at Nimbus and Trinity River fish hatcheries that were diminishing the long-term viability of non-listed CV Chinook salmon stocks, the RPA called for the development of hatchery management plans for fall-run Chinook salmon at Nimbus Fish Hatchery and for CV spring-run and fall-run Chinook salmon at Trinity River Fish Hatchery by June 2014. NMFS anticipated that these actions would reduce impacts of hatchery operations on natural fall-run and spring-run CV Chinook salmon, increase the genetic diversity and diversity of run-timing for

these stocks, and increase the likelihood that these stocks would be retained as prey available to SRKWs in the long term. As part of the 2019 proposed action, Reclamation proposed to conduct habitat restoration projects in the Sacramento River, American River, and Stanislaus River through 2030. We anticipate that an increase in habitat should help to offset impacts from water operational factors and improve conditions for naturally produced CV Chinook salmon.

An HGMP was developed for the Trinity River Fish Hatchery in 2020. Although not required in the RPA for the 2009 Opinion, the USFWS completed an HGMP for the Coleman National Fish Hatchery in 2014 and for the LSNFH in 2017. The Nimbus HGMP was not completed by 2014 as required in the RPA. Reclamation proposed completion of the HGMP as part of the proposed action in 2019; however, that work has still not been completed and is not being proposed as part of this action.

Production of non-listed CV fall-run Chinook salmon is the largest contributor of hatchery-origin Chinook salmon in the state, with a total combined release of nearly 30 million smolts annually. Ongoing hatchery production at current levels is expected to continue to negatively affect the survival, productivity, and genetic diversity of naturally produced Chinook salmon in the Central Valley. Continued implementation of the HGMPs that have been developed since 2009 are expected to minimize these impacts. The development of an HGMP for the Nimbus Fish Hatchery would be expected to aid in this minimization. Although hatchery production represents the primary component of CV Chinook salmon abundance in the ocean (Figure 155), NMFS must consider the long-term viability of natural origin ESUs in determining the effects of hatchery production on SRKWs.

7.6.1.3. Adult Chinook Salmon Ocean Abundance

In order to model the impacts of the proposed action on the ocean abundance of adult CV Chinook salmon, we first examined the relative contribution of hatchery production (released in-river and trucked directly into San Francisco Bay as described above) and natural production to recent ocean abundances of CV Chinook salmon. Using the median annual ocean abundance of CV Chinook salmon for the period 2001–2022 of 394,914 (age 3+; Table 150), along with the assumed hatchery proportion of 0.74, and the estimated number of hatchery-produced Chinook salmon that survive to and/or are released into San Francisco Bay under current conditions (15,424,758), the estimated survival rate of juvenile Chinook salmon smolts in San Francisco Bay to the adult stage in the ocean (age 3+) is 0.0189 (Appendix C of this opinion). In addition, using this same information, we estimate that the annual contribution of naturally produced CV Chinook salmon in San Francisco Bay would have been 5,419,509 juvenile smolts.

To determine the effects of the proposed action on the abundance of adult CV Chinook salmon available to SRKWs as prey in the ocean, we combined the upstream and Delta survival effects under the proposed action as well as the SIT lifecycle model results for all hatchery- and naturally produced CV Chinook salmon to estimate the number of juvenile fish that survive through the system to the Bay in a given year. We then used the estimated smolt to adult survival ratio of 0.0189 to estimate the number of adult (age 3+) CV Chinook salmon available to SRKWs as prey in the ocean under the proposed action. Using estimates of ocean abundance from 2001 to 2022, the estimated median ocean abundance of adult CV Chinook salmon under the Alt2v2 operating scenario with Delta VAs for at least the first 2 years of the proposed action would be 393,427, 95% CI [380,576, 412,070] (Table 152; Appendix C of this opinion).

Reclamation has proposed to implement the Alt2v1 operating scenario without the contribution of any VA assets after the first 2 years of the proposed action. On October 23, 2024, NMFS received a modified proposed action (Appendix A of this opinion) in which Reclamation indicated their intention to continue operations under the Alt2v2 operating scenario for longer if VAs are approved by the SWRCB. Alt2v2 may continue without interruption even if VAs have not been approved, as long as substantial progress is being made on them by year 2. Still, it is possible that the Atl2v1 operating scenario could be implemented for up to 8 years. Under Alt2v1, the estimated median ocean abundance of adult CV Chinook salmon would be 395,355 (95% CI [478,701, 412,205], Table 152, Appendix C of this opinion). Under both operating scenarios, this represents a very broad range in potential abundance over 95 percent of the modeled observations.

In order to relate the comparative impact of the proposed action to current operations in terms of the overall ocean abundance of CV Chinook salmon, we compared the estimated abundances under Alt2v1 and Alt2v2 to the modeled abundance under the NAA scenario, which is assumed to represent the current operating scenario if it were continued into the future. Under the NAA scenario, the estimated median abundance of adult CV Chinook salmon would be 394,914 fish (95% CI [385,249, 417,928], Table 152, Appendix C of this opinion). The Alt2v2 operating scenario would be expected to result in a median reduction of 0.38 percent fewer fish (1,487 adult Chinook salmon) per year. Alt2v2 could result in an annual reduction of as many as 3.63 percent fewer fish (14,338 adult Chinook salmon) at the 2.5th percentile, or an annual increase of as many as 4.34 percent more fish (17,156 adult Chinook salmon) at the 97.5th percentile. If Alt2v2 is not extended beyond the first 2 years of the proposed action, the Alt2v1 operating scenario would be expected to result in a median increase of approximately 0.11 more fish (440 adult Chinook salmon) per year. Alt2v1 could result in an annual reduction of as many as 4.11 percent fewer fish (16,213 adult Chinook salmon) at the 2.5th percentile, or an annual increase of as many as 4.38 percent more fish (17,291 adult Chinook salmon) at the 97.5th percentile (Table 152, Appendix C of this opinion). These trends are largely driven by effects on fall-run Chinook salmon, with changes to CV spring-run and SR winter-run Chinook salmon estimated to be much smaller in magnitude (Table 153).

The model estimates, however, contain several known sources of uncertainty. For example, some stressors are not readily quantifiable and, therefore, were not incorporated into the upstream survival models, and some small portions of the CV system could not be evaluated given the available data. Estimates of pre-harvest ocean adult CV Chinook salmon also display a high level of variability from year to year, with a standard deviation of 454,430 fish around the mean of 596,959 fish from 2001 to 2022. Therefore, we recognize the median estimates may not be representative of the extent of relative changes in impacts under the proposed action, but serve as the best available estimate of proposed action effects on available prey.

The PFMC estimated 1,552,110 Chinook salmon along the coasts of Washington, Oregon, and California in 2024 (Pacific Fishery Management Council 2024b). If the proposed action reduces CV Chinook by a median of -0.494 percent, or approximately 1,950 fish per year, this would constitute a 0.13 percent median reduction in the total number of Chinook available to SRKWs as prey along the U.S. West Coast. This is likely an underestimate of the change in prey available to SRKWs as a result of the proposed action because the areas in which SRKWs forage off the coast are smaller than the area encompassed by the PFMC total Chinook salmon abundance estimate, and the non-summer months when SRKWs forage in this region have been identified as

a time of year with low Chinook salmon prey availability for SRKWs. Therefore, the magnitude of prey reduction compared to the total prey base is still small, but likely larger than this quantitative estimate.

Table 152. Estimated median adult Chinook salmon abundance available as prey for Southern Resident Killer Whales under each modeled operating scenario.

Run	EXP3	NAA	Alt2v1	Alt2v2	Alt2v3	EXP1
Fall and Late Fall	5,339,827	5,315,072	5,238,796	5,221,040	5,222,052	5,401,270
Fall and Late Fall Hatchery Trucked	13,020,000	13,020,000	13,020,000	13,020,000	13,020,000	13,020,000
Fall and Late Fall Hatchery Released	1,236,281	1,238,124	1,327,844	1,253,484	1,253,484	1,490,348
Sacramento River Winter	31,821	31,397	31,297	31,425	31,764	76
Winter Hatchery Released	3,162	3,264	3,492	3,264	3,264	4,400
Central Valley Spring	74,138	73,040	73,139	73,199	73,487	76,490
Spring Hatchery Trucked	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000
Spring Hatchery Released	163,540	163,370	172,980	163,370	163,370	191,600
Total Freshwater Survival	20,868,769	20,948,704	20,867,548	20,765,781	20,767,421	21,184,184
Ocean Adult Chinook Abundance	**395,378**	**394,914**	**395,355**	**393,427**	**393,458**	**401,354**
Change Relative to NAA	464	NA	441	-1,487	-1,456	6,440
% Change Relative to NAA	0.12	NA	0.11	-0.38	-0.01	1.63
2.5th Percentile Ocean Adult Abundance	371,623	385,249	378,701	380,576	380,501	377,379
97.5th Percentile Ocean Adult Abundance	430,347	417,928	412,205	412,070	412,835	426,589

Table 153. Estimated median adult Chinook salmon abundance by season available as prey for Southern Resident Killer Whales under each modeled operating scenario.

Run	EXP3	NAA	Alt2v1	Alt2v2	Alt2v3	EXP1
Fall and Late Fall Juveniles Total	19,596108	19,573,196	19,586,640	19,494,523	19,495,536	19,911,618
Fall and Late Fall Ocean Adult Chinook Abundance	371,267	370,833	371,087	369,342	369,361	377,244
Fall and Late Fall Change Relative to NAA	434	NA	254	-1,491	-1,472	6,411
% Change Relative to NAA	0.12	NA	0.07	-0.40	-0.40	1.73
Winter Juveniles Total	34,983	34,661	34,789	34,689	35,028	4,476
Winter Ocean Adult Chinook Abundance	663	657	659	657	664	85
Winter Change Relative to NAA	6	NA	2	0	7	-572
% Change Relative to NAA	0.91	NA	0.30	0	1.07	-87.06
Spring Juveniles Total	1,237,678	1,236,410	1,246,119	1,236,569	1,236,857	1,268,090
Spring Ocean Adult Chinook Abundance	23,449	23,425	23,609	23,428	23,433	24,025
Spring Change Relative to NAA	24	NA	184	3	8	600
% Change Relative to NAA	0.10	NA	0.79	0.01	0.03	2.56

7.6.1.4. Summary of Project Effects on Southern Resident Killer Whale Prey

7.6.1.4.1. Exposure: Effects of the Proposed Action on Prey Abundance

There has been an ongoing apparent decline in the relative abundance of Chinook salmon over the last 22 years for most Chinook salmon ESUs in the Central Valley, which has been occurring in concert with ongoing CVP and SWP operations along with other significant factors described in the Environmental Baseline section (Figure 155). This is especially true for the dominant fall-run Chinook salmon populations, where escapement during most of the last 15 years has been substantially lower than previous time periods (Figure 156), primarily due to the effects of droughts. The proposed action includes activities expected to be both harmful to and protective of Chinook salmon. Harmful activities are associated with flow management and Delta export operations, while protective measures include pulse flows and other adaptively managed actions. Analysis of effects on ESA-listed SR winter-run and CV spring-run Chinook salmon are provided in previous sections of this opinion. For non-ESA-listed ESUs, the proposed action will likely continue to lead to diminished productivity and abundance of fall- and late fall-run Chinook salmon.

CV Chinook salmon constitute a sizable proportion of the total abundance of Chinook salmon in the SRKW diet in the winter and spring months. CV Chinook salmon become an increasingly significant portion of the prey source during any southerly movements of SRKWs along the coast of Oregon and California that may occur during the winter and spring, and CV fall-run Chinook salmon can be expected to constitute at least 25 percent of the local abundance in many places throughout this area at any time (Bellinger et al. 2015), and are expected to constitute well over 50 percent of the local abundance of Chinook salmon in some areas off California when SRKWs are present there (Shelton et al. 2019).(Emmons et al. 2021)used genetic analysis of prey remains and fecal samples to determine the stock composition of SRKW prey in their coastal habitat in the fall, winter, and spring months from 2007 through 2014. They found that although CV Chinook salmon make up approximately 20 percent of the SRKW diet from February through April, the contribution varies by stock and proportion in each of those months. The dominant CV stock in February and March was observed to be CV spring-run Chinook salmon with 18.3 ± 11 percent of the February diet and 11.7 ± 9 percent of the March diet composed of CV spring-run Chinook salmon. In April, 26.6 ± 17.1 percent of SRKW diet is composed of CV fall-run Chinook salmon, with no CV spring-run Chinook salmon detected in that month (Hanson et al. 2021). In February and March, when CV spring-run Chinook salmon dominated the stocks from the Central Valley in samples analyzed, the mean contribution of fall-run Chinook salmon was zero, however, the standard error for those months was 15 and 6 percent, respectively. SR winter-run Chinook salmon were not detected in the diet (Hanson et al. 2021). They also observed CV fall-run Chinook salmon in about 5 percent of the prey samples collected in the Puget Sound. CV fall-run Chinook salmon have been detected as far north in SRKW's range as Northwest Vancouver Island (Shelton 2021).

Relative to current operations, the change in CV Chinook salmon abundance in the ocean is estimated to be relatively small (less than 1 percent median estimate). The reductions in Chinook salmon productivity that are estimated by the models through various portions of their life-stage, and in-total through the Central Valley system to the ocean, are not necessarily large for most

years, including variable impacts on natural and hatchery production released into the Central Valley. Expectations are that there will be almost 1,500 less adult CV Chinook salmon per year in the ocean under at least the first 2 years of the proposed action. This level of impact may continue beyond the first 2 years if the VAs are signed. While the available models do incorporate some of the key stressors identified for CV Chinook salmon populations, some stressors are not readily quantifiable and/or cannot be incorporated into these models, and some portions of the Central Valley system could not be evaluated given the available data. Therefore, there is a high level of uncertainty associated with this estimate, ranging from potential decreases in adult ocean Chinook salmon abundance of 3.63 and 4.11 percent to potential increases of 4.38 and 4.34 percent.

7.6.1.4.2. Response: Effects of Reduced Prey on Southern Resident Killer Whales

To date, the available data and analyses have not supported an analytical approach that statistically quantifies the effects of changes in Chinook salmon abundance to SRKW survival and recovery (i.e., mortality and reproduction). In the absence of a predictive analytical tool to evaluate this relationship, we use a weight-of-evidence approach to consider all of the information we have—identifying a variety of metrics or indicators with varying degrees of confidence (or weight)—to assess the impacts of the proposed action. First, we briefly discuss and summarize what is known about the relationship between SRKWs and their primary prey, Chinook salmon, and methods used to explore these relationships, and why we do not rely more extensively on direct correlations in our analysis of quantitative impacts of the proposed action on prey availability, but rather, instead rely on this weight-of-evidence approach. We then discuss our evaluation of the potential long-term effects of changes in prey availability from the proposed action. The analysis also highlights our level of confidence in the available data, and identifies where there is uncertainty in light of data gaps and where we made conservative assumptions.

Qualitatively, with respect to short-term effects, SRKWs could abandon particular areas where prey resources are limited and/or have been reduced in search of more abundant prey or expend substantial effort to find prey resources in response to a decrease in the amount of available Chinook salmon due to the proposed action. These changes in behavior can result in increased energy demands for foraging individuals, as well as reductions in overall energy intake, increasing the risks of being unable to acquire adequate energy and nutrients from available prey resources (i.e., nutritional stress). SRKWs are known to consume other species of fish, including other salmon, but the relative energetic value of these species is substantially less than that of Chinook salmon. Reduced availability of Chinook salmon would likely increase predation activity on other species (and energy expenditures) and/or reduce energy intake. With respect to longer-term effects, numerous studies have demonstrated the effects of energetic stress (caused by incremental increases in energy expenditures or incremental reductions in available energy) leading to reduced body size and condition and lower reproductive and survival rates for adults (e.g., Daan et al. [1996] and Gamel et al. [2005]) and juveniles (e.g., Noren et al. [2009] and Trites and Donnelly [2003]). In the absence of sufficient food supply, adult females may not successfully become pregnant or give birth and juveniles may grow more slowly. Any individual may lose vitality, succumb to disease or other factors as a result of decreased fitness, and subsequently die or not contribute effectively to the future productivity of offspring, which is necessary to avoid extinction and promote the recovery of a population.

There are several challenges to quantitatively characterizing the relationship between SRKWs and Chinook salmon and the impacts of reduced prey availability on SRKW's behavior and health. Attempts to compare the relative importance of any specific Chinook salmon stock or stock groups using the strength of statistical relationships have not produced clear distinctions as to which stocks are most influential, and most Chinook salmon abundance indices are highly correlated with each other. Different Chinook salmon populations are likely more important in different years. Large aggregations of modeled Chinook salmon stocks that reflect abundance on a more coast-wide scale have previously appeared to be equally or better correlated with SRKW vital rates than smaller aggregations of Chinook salmon stocks, or specific stocks such as Chinook salmon originating from the Fraser River that have been positively identified in diet samples as key sources of prey for SRKWs during certain times of the year in specific areas (see Hilborn et al. 2012, Ward et al. 2013). For example, low coastwide Chinook salmon abundance in the late 1990s corresponded to an approximate 20-percent decline in the SRKW population, constrained body growth, and low social cohesion as described in the Status of the Species section. So, though it is difficult to identify a low abundance that is predicted to cause adverse effects to SRKWs, there is evidence that SRKWs and other killer whale populations known to consume Chinook salmon may have experienced adverse effects from low Chinook prey availability beginning in the late 1990s, likely due to common factors affecting changes in the populations (National Marine Fisheries Service 2008d), (Towers et al. 2015).

The effects of reductions in Chinook salmon abundance are likely a more significant risk to SRKWs at relatively low levels of Chinook abundance, and this likely also depends on the status of SRKWs at the time. Past efforts have recognized the likely greater risk to SRKWs in low Chinook salmon abundance years (Pacific Fishery Management Council 2020). Populations with healthy individuals may be less affected by changes to prey abundance than populations with less healthy individuals (i.e., there may be a spectrum of risk based on the status of the whale population). Because SRKWs are already stressed due to the cumulative effects of multiple stressors, and the stressors can interact additively or synergistically, any additional stress, such as reduced Chinook salmon abundance, likely has a greater physiological effect than it would for a healthy population, which may have negative implications for SRKW vital rates and population viability (e.g., National Academy of Sciences, Engineering, and Medicine 2017). Intuitively, at some low Chinook salmon abundance level, the prey available to SRKWs may not be sufficient to allow for successful foraging, leading to adverse effects (such as reduced body condition and growth and/or poor reproductive success). This could affect SRKW survival and fecundity. For example, food scarcity could cause whales to draw on fat stores, mobilizing the relatively high levels of contaminants stored in their fat and potentially affecting reproduction and immune function (Mongillo et al. 2016). Increasing time spent searching for prey during periods of reduced prey availability may decrease the time spent socializing; potentially reducing reproductive opportunities. Also, low abundance across multiple years may have an even greater effect because SRKWs likely require more food consumption during certain life stages, female body condition and energy reserves potentially affect reproduction and/or result in reproductive failure at multiple stages of reproduction (e.g., failure to ovulate, failure to conceive, miscarriage, failure to successfully nurse calves, etc.), and effects of prey availability on reproduction should be combined across consecutive years. Good fitness and body condition coupled with stable group cohesion and reproductive opportunities are important for reproductive success.

Furthermore, on top of the difficulties in identifying a robust quantitative model that identifies a low abundance threshold that is predicted to cause adverse effects to SRKWs, there are also difficulties in estimating the total amount of Chinook salmon needed by SRKWs to meet their metabolic needs. Though there are estimates of the metabolic needs of the population of SRKWs that we cite throughout this opinion (such as Noren 2011, Williams et al. 2011, and Chasco et al. 2017a; see the Environmental Baseline section), these estimates can vary based on several underlying assumptions including the size of the whale population and the caloric density of the salmon. Also, as noted in the Environmental Baseline section, given the lack of available information on the whales' foraging efficiency, it is difficult to evaluate how much Chinook salmon or what density of salmon needs to be available to the whales for their survival and successful reproduction. The whales and prey are both highly mobile and have large ranges with variable overlap seasonally. It is also currently uncertain how other factors in their environment, such as vessel presence, further impact their foraging efficiency and, therefore, the amount of prey needed throughout their habitat. New analysis by Holt et al. (2021b) found that the probability of prey capture for SRKWs increased as prey abundance increased (both Chinook and coho salmon), highlighting the importance of prey availability in meeting caloric needs. Though there are general estimates of how many Chinook salmon need to be consumed to meet the biological needs of the whales, we do not have estimates of the total amount needed in their environment or what density is needed for the population to be able to consume this amount. Therefore, we are unable to quantify how any reduction in the number of adult Chinook salmon in the ocean by the proposed action affects foraging efficiency of the whales and are limited in our interpretation of these values. Thus, we apply a low weight to analysis on energetic requirements of the whales and calorie availability of prey when assessing the effects of the action.

Although there is currently no robust quantitative model for a low Chinook salmon abundance threshold, the PFMC recently adopted an amendment to the salmon FMP that includes an identified low abundance threshold for Chinook salmon abundance in coastal salmon fisheries north of Cape Falcon, Oregon (Amendment 21 to the FMP; National Marine Fisheries Service 2021c) recognizing likely greater risk to SRKW in low abundance years. The threshold was based on one statistically significant relationship between SRKW viability parameters and Chinook salmon abundance in the north of Cape Falcon management area. Amendment 21 to the FMP is designed to minimize the effects of PFMC fisheries on prey availability and address the concerns for disproportionately high percent prey reductions in years of particularly low Chinook salmon abundance in times and areas where/when the fisheries and whales overlap and potential for localized depletion by fisheries in SRKW foraging locations. The threshold used is based on years included in the Workgroup's analysis when Chinook salmon abundance was relatively low and there was a general mix of SRKW status (i.e., consisting of a spectrum of risk), with 2 relatively good status years (1994 and 2007) and 5 years of fair or poor SRKW status, as well as including two periods when there were multiple and consecutive years of low Chinook salmon abundance (1995–1996 and 1998–2000). If prey availability is low on the coast (particularly below the threshold), and abundance is low or depletion occurs in foraging hot spots, SRKWs may increase searching efforts in other areas within their geographic range, including in the Salish Sea (though management actions associated with Amendment 21 may help reduce depletion in hot spots).

7.6.1.4.3. Risk: Effects of the Proposed Action on Southern Resident Killer Whales

The information described previously in this opinion suggests that the health of individual animals and the overall population dynamics of SRKWs are related to the abundance of Chinook salmon available as prey throughout the range of SRKWs. Reductions in the availability of preferred prey (Chinook salmon) would be expected to influence the behavior and potentially affect the fitness of individual SRKWs, and may affect the survival and reproductive success of SRKWs. As described in Section 4.9.2 _, Southern Resident Killer Whale, during the winter and spring, members of K and L pod, in particular, are likely to spend at least some time in coastal waters off of California where they would be most affected by reductions in CV Chinook salmon abundance due to the proposed action. Body condition data collected using photogrammetry suggest that these winter and spring months may be a time of low prey availability, resulting in seasonally poorer body condition, particularly among younger individuals (Fearnbach et al. 2019). As described in Section_4.9.1, Southern Resident Killer Whale, the number of reproductive-aged females in K and L pods has declined over time while the number of reproductive-age females in J pod has increased over that same period (Figure 17). These population dynamics could further exacerbate the impacts of reduced prey availability on the reproductive success of the two pods as a result of the proposed action.

As described in Section 4.9.3.1.4, Southern Resident Killer Whale, NMFS and WDFW developed a priority stock report identifying the most important Chinook salmon stocks along the West Coast (National Marine Fisheries Service and Washington Department of Fish and Wildlife 2018). Of the CV Chinook salmon stocks, CV spring-run Chinook salmon was determined to be the highest priority, followed by fall-run Chinook salmon and then SR winter-run Chinook salmon. SR winter-run Chinook salmon received the lowest score in the model due to the lack of samples documenting the presence of the ESU in the SRKW diet, however this may be due to the small size of the ESU and the small sample size of foraging events off the coast. Spatio-temporal overlap between SRKWs and SR winter-run Chinook salmon supports the hypothesis that SR winter-run Chinook salmon do contribute in some part to SRKW diet. Table 153 demonstrates the effects to each run compared to the NAA scenario as a result of the proposed action. Alt2v2 results in a median reduction in adult fall-run Chinook salmon of about 0.4 percent (1,491 adult Chinook salmon) per year, a median increase in adult CV spring-run Chinook salmon of 0.01percent (3 adult Chinook salmon) per year, and no change in the abundance of CV winter-run Chinook salmon. Alt2v1 results in a median increase in adult fall-run Chinook of about 0.07 percent (254 adults), a median increase in adult CV spring-run Chinook salmon of about 0.79 percent (184 adults), and a median increase in adult CV winter-run Chinook salmon of about 0.3 percent (2 adults).

Reclamation proposes to operate under the Alt2v2 scenario for at least the first 2 years, longer if VAs are signed by all relevant parties. This would represent an overall median reduction of up to 0.38 percent (1,487 adult Chinook salmon) annually; however, years in which the Alt2v1 operating scenario is utilized would result in a median increase of 0.11percent (441 adults) expected per year. The median reduction under Alt2v2 is greater than the year-over-year reduction observed as a result of CVP and SWP operations in the past (National Marine Fisheries Service 2019b), and may result in the short- and long-term impacts to SRKWs from reduced prey availability discussed above. The large range in potential abundance observed under both operating scenarios from the 2.5th percentile to the 97.5th percentile represents a high level of uncertainty around these median estimates.

7.6.2. Effects of the Action on Southern Resident Killer Whale Critical Habitat

In addition to the direct and indirect effects to SRKWs discussed above, the proposed action affects critical habitat designated for SRKWs along the West Coast and in the inland waters of Washington State. Based on the natural history of the SRKWs and their habitat needs, we identified three PBFs essential to conservation in designating critical habitat: (1) Water quality to support the growth of the whale population and development of individual whales; (2) Prey species of sufficient quantity, quality and availability to support individual growth, reproduction and development, as well as overall population growth; and (3) Passage conditions to allow for migration, resting, and foraging. The proposed action has the potential to affect the second PBF.

The critical habitat feature related to prey includes prey quantity, quality, and availability and this analysis draws on the analysis of the effects on prey to the whales themselves. The proposed action has the potential to affect the quantity and, therefore, availability of prey, but likely little effect on prey quality. We would not expect any impacts from the proposed action on the quality of prey with respect to levels of harmful contaminants or the energy content of CV Chinook salmon as a result of changes in age composition or size-at-age of CV stocks. As described in the Effects section above, the proposed action is expected to cause an approximate 0.38-percent median reduction in the abundance of adult (age 3+) Chinook salmon in designated coastal critical habitat in 2 or more years of the proposed action. Years in which Alt2v1 is implemented could result in a slight increase in the number of adult CV Chinook available as prey to SRKWs (0.11 percent or 441 fish per year of implementation), however Reclamation has indicated an intention to negotiate with the SWRCB to sign VAs for more than the first 2 years of the proposed action. The starting abundance of CV Chinook salmon is 36 percent less than the previous 10-year average.

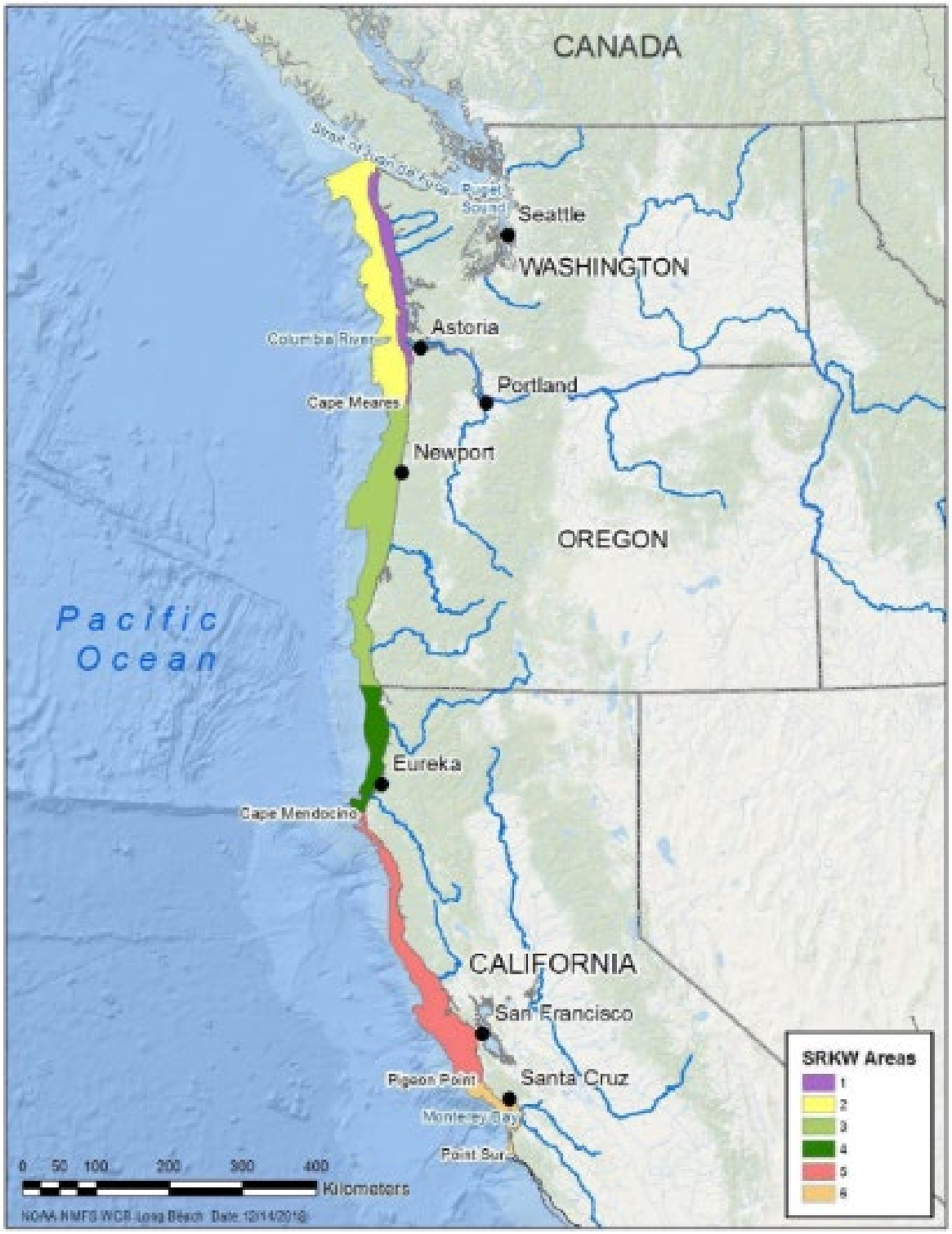


Figure 157. Specific areas of Southern Resident Killer Whale coastal critical habitat.

Although Pacific salmon return to their natal rivers to spawn, the 3 to 5 years, on average, of their lives spent in the ocean is marked by a long migration and few surveys of ocean distribution and abundance at the stock level exist (Shelton et al. 2018, Shelton 2021). Furthermore, the impacts of climate change on the distribution and abundance of anadromous fish in their ocean habitat are not as well-studied as the impacts of climate change on the freshwater life history of those species (Shelton 2021). Therefore, it is difficult to assess quantitatively how reductions in prey abundance may vary throughout SRKW critical habitat on a small geographic scale, and we have less confidence in our understanding of how reductions could result in localized depletions in specific areas of critical habitat, especially in the inland waters of Washington State where CV Chinook salmon has been documented in approximately 5 percent of the prey samples collected (Hanson et al. 2021). The greatest effects will likely be realized in areas of higher spatial and temporal overlap between SRKWs and CV Chinook salmon within the SRKW designated critical habitat. Six specific areas of SRKW coastal critical habitat have been delineated based on their habitat features and use by SRKWs (National Marine Fisheries Service 2021h, Figure 157). While Hanson et al. (2021) found that SRKWs largely consumed Chinook salmon near the fish's natal rivers, CV Chinook salmon was documented in SRKW prey samples as far north as Areas 1 and 2, north of Cape Meares, both of which are high-use areas for all three SRKW pods (Figure 157; Hanson et al. 2021, National Marine Fisheries Service 2021h). Unsurprisingly, CV and Klamath River Chinook salmon make up about 50 percent of the fish present in Area 4, north of Cape Mendocino, where all three prey samples collected near foraging SRKWs were identified as spring and fall-run CV Chinook salmon (Shelton et al. 2018, Hanson et al. 2021). Although no prey sampling has been conducted in Area 6, off the coast of Santa Cruz, to inform the SRKW diet composition in this region, Shelton et al. (2018)estimate that CV Chinook salmon make up between 50 and 75 percent of fish present. Therefore, it is likely that the greatest effects to SRKW critical habitat as a result of the proposed action would occur in Areas 4 and 6; however, reductions in CV Chinook salmon prey are likely to be distributed throughout SRKW coastal and inland critical habitat. The proposed action is thus likely to impact SRKWs in all areas of their coastal critical habitat, as well as their inland critical habitat.

7.7. Life Cycle Model Analysis

Life cycle models of SR winter-run Chinook salmon and CV spring-run Chinook salmon are used to analyze how the multiple effects of the proposed action affect the vital rates of population abundance, cohort replacement rate (CRR), habitat use distribution, and juvenile survival. These models characterize the dynamics of multiple life stage transitions, including eggs, fry, smolts, juveniles in the ocean, and mature adults returning to spawning grounds. The life cycle models considered in this consultation are the IOS model, the OBAN model, and the CVPIA Decision Support Model (DSM) for both SR winter-run and CV spring-run Chinook salmon, the results for which were provided by Reclamation (as supplemental LTO BA modeling information). Also considered is the NMFS SWFSC's WRLCM. These models provide a more holistic evaluation in their examination of the effects of the action because the models consider the collective effects of multiple action components across sequential life cycles, thereby providing demographic information related to species viability. While the hydrologic modeling results that feed into the life cycle models (e.g., CalSim 3, HEC-5Q, DSM2-Hydro, etc.) do not capture or reflect the entirety of conditions associated with any modeled scenario, these models are considered the best available tools for assessing the effect of those conditions on Central Valley salmon.

The unique set of results from the life cycle models are presented here instead of being integrated into, and possibly attributed to, an individual proposed action component. The results reflect the population-level attributes of abundance, productivity, and population trend rather than just an individual's response described as a relative change in fitness. Life cycle model results are provided for the proposed action, the NAA, and EXP3. The NAA scenario represents the past, discretionary and non-discretionary effects of project operations. EXP3 includes the past and future non-discretionary effects that may be used to compare either current operations or the proposed action to discern the modeled discretionary effects of project operations.

The analyses presented in this section incorporate the underlying uncertainties embedded in the modeling of the scenarios such that a comparative analysis of the scenarios will effectively discount the effect of that uncertainty. The comparative analysis is also useful in understanding the overall direction of modeled effects and assessing predicted trends on population structure and viability. As discussed in the Analytical Approach section, this comparative analysis should not be conflated with an analysis of the full effects of proposed project operations on species. The Integration and Synthesis section of this opinion discusses how NMFS considers the life cycle model results, in addition to other information, in evaluating the operational effects of the proposed action to species in aggregate with the cumulative effects and the effects of the baseline.

7.7.1. Interactive Object-Oriented Simulation (IOS) Model

The IOS model provided by Reclamation (Appendix F. LCA IOS in U.S. Bureau of Reclamation 2023-2024) is composed of six model stages defined by a specific spatiotemporal context, which are arranged sequentially to account for the entire life cycle of SR winter-run Chinook salmon, from eggs to returning spawners. In sequential order, the IOS model stages are:

1. Spawning, which models the number and temporal distribution of eggs deposited in the gravel at the spawning grounds in the Upper Sacramento River between Red Bluff Diversion Dam and Keswick Dam
2. Early Development, which models the effect of temperature on maturation timing and mortality of eggs at the spawning grounds
3. Fry Rearing, which models the relationship between temperature and mortality of fry during the river rearing period in the Upper Sacramento River between Red Bluff Diversion Dam and Keswick Dam
4. River Migration, which estimates the mortality of migrating smolts in the Sacramento River between the spawning and rearing grounds and the Delta
5. Delta Passage, which models the effect of flow, route selection, and water exports on the survival of smolts migrating through the Delta to San Francisco Bay
6. Ocean Survival, which estimates the effect of natural mortality and ocean harvest to predict survival and spawning returns by age

7.7.1.1. Interactive Object-Oriented Simulation Model Results

For the first 4 years of the 100-year simulation period, a starting population of 5,000 spawning adults is used to analyze the scenarios, of which 3,088 are female based on the wild male-to-female ratio of spawners from CDFW carcass survey reports. In the fifth year, the number of female spawning adults is determined by the model's probabilistic simulation of survival to this

life stage. To ensure that the developing fish experience the correct environmental conditions each year, spawn timing is determined by a function of water temperatures in April and May, as described by Dusek Jennings (2020). Eggs deposited on a particular date are treated as cohorts that experience temperature on a daily time step during the early development stage. The daily number of female spawners is calculated by multiplying the predicted daily proportion of spawners by the total Jolly-Seber estimate of female spawners (Poytress and Carrillo 2010).

IOS model results show that egg survival is generally very high in all water year types except critical years where egg survival decreases substantially. The lowest mean predicted egg survival of SR winter-run Chinook salmon for the proposed action (Alt2v1) occurs in critical water years (68.4 percent), and the highest occurs in every other year type where survival is expected to be 100 percent. Likewise results from the NAA show that egg survival in critical years is lowest (69.8 percent) with all other year types having high survival (100 percent, Figure 158).

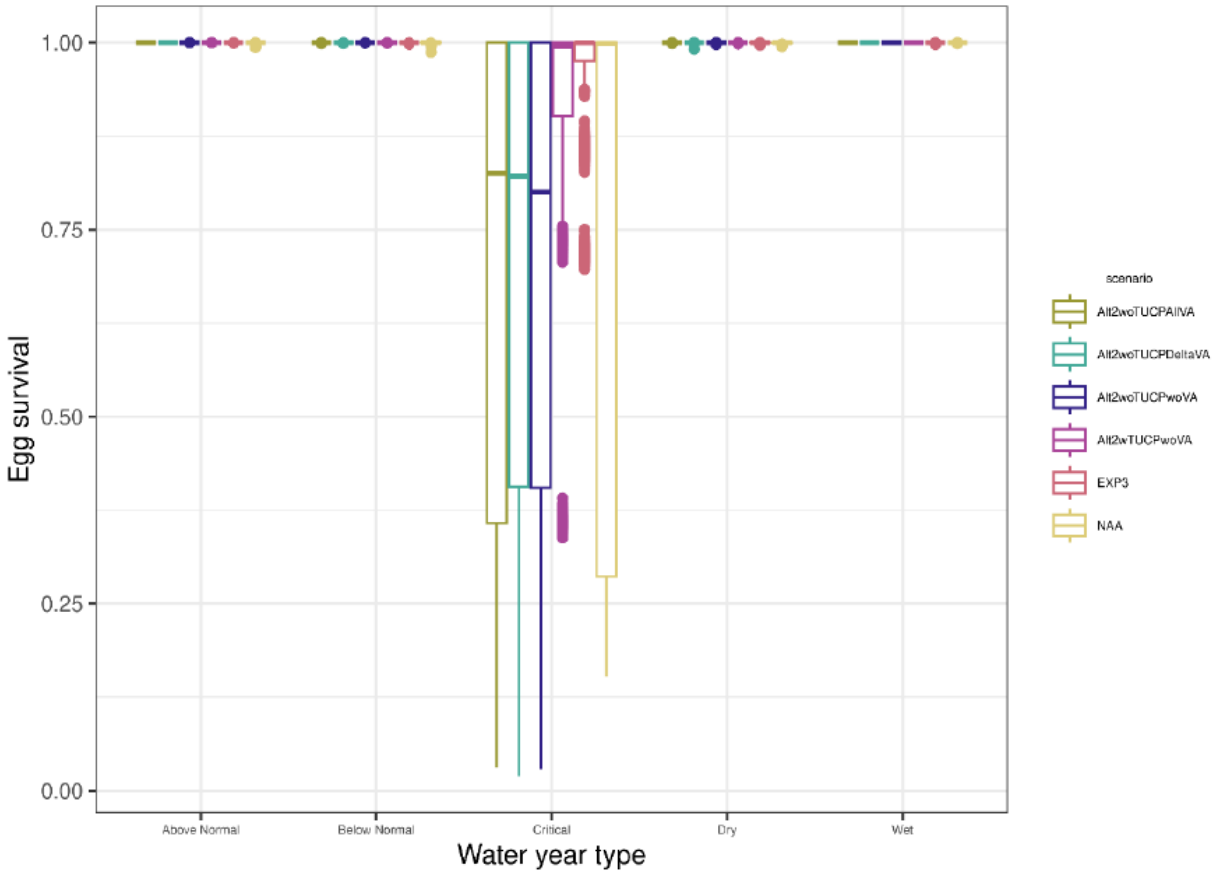


Figure 158. Boxplots showing predicted Sacramento River winter-run Chinook salmon egg survival by water year type.

Source: (Appendix F. LCA IOS.pdf in U.S. Bureau of Reclamation 2023-2024)

Data from U.S. Fish and Wildlife Service (1999) are used to model fry mortality during rearing as a function of water temperature. Each day, the mean proportional mortality of the rearing fish is predicted from the daily water temperature, where the predicted mean mortality, along with the confidence intervals of the predicted values, is used to define a normal probability distribution,

which then is randomly sampled to determine the daily mortality of the rearing fish. Temperature mortality is applied to rearing fry for 60 days, the approximate time required for fry to transition into smolts (U.S. Fish and Wildlife Service 1999) and enter the river migration stage. All fish migrating through the Delta are assumed to be smolts.

The IOS model results for the proposed action show that the mean predicted fry survival of SR winter-run Chinook salmon is high across all year types except in critical years. For all water year types except critical, mean fry survival is about 96 percent. In critical year types, which are expected in about 15 percent of years, the lowest mean predicted fry survival of SR winter-run Chinook salmon is 61.3 percent (Figure 159). These results are almost identical to those of the NAA where all water year types except critical have a mean fry survival of about 96 percent and the predicted fry survival in critical water years is 65.2 percent.

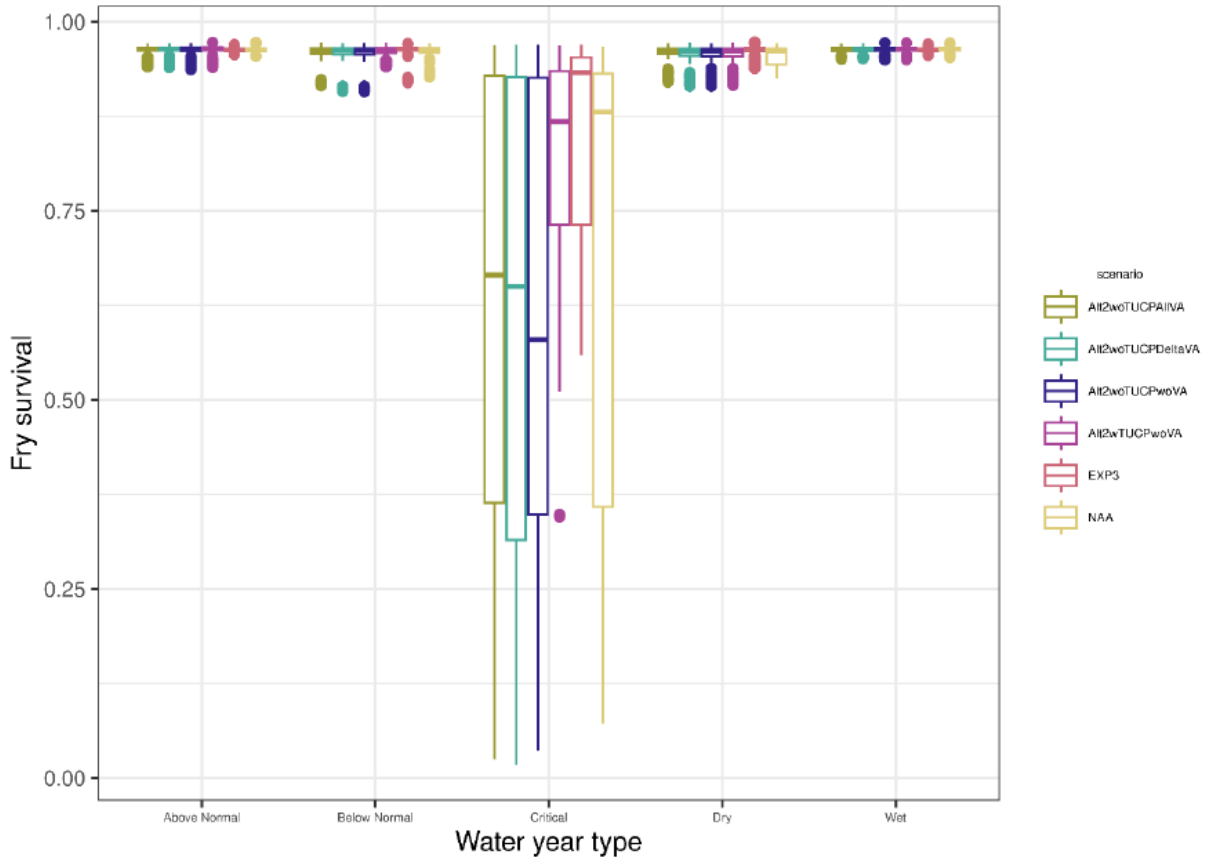


Figure 159. Boxplots showing predicted Sacramento River winter-run Chinook salmon fry survival by water year type.

Source: (Appendix F. LCA IOS.pdf in U.S. Bureau of Reclamation 2023-2024)

The IOS model estimates survival of smolts between Red Bluff Diversion Dam and Fremont Weir as a function of flow at Bend Bridge. The flow-survival relationship in this reach was modeled using 7 years of releases of SR winter-run Chinook salmon smolts from LSNFH that were implanted with Juvenile Salmon Acoustic Telemetry System transmitters (total of 2,912 tagged fish detected at Red Bluff Diversion Dam). The domain considers flows ranging from

about 2,000 cfs up to 60,000 cfs correlated with river migration survivals ranging from about 24 percent to 39 percent. Mortality at this life history stage is applied on the day fish pass Red Bluff Diversion Dam, with the specific value estimated based on flow at Bend Bridge. The model results show very small differences between scenarios in mean predicted river-migration survival of SR winter-run Chinook salmon. A general trend includes increasing survival probabilities with wetter hydrologies, reflecting the linear interpretation of the flow survival relationship. For context, the proposed action performs less well than the NAA (Table 154), but the relative difference in mean predicted river-migration survival between the two scenarios is minimal—less than 0.4 percent.

Table 154. Predicted mean Sacramento River winter-run Chinook salmon through-river-migration survival by water year type.

Water Year Type	NAA	Alt2v1	Alt2v2	EXP3
Above Normal	0.27	0.269	0.269	0.28
Below Normal	0.25	0.253	0.253	0.26
Critical	0.25	0.247	0.247	0.25
Dry	0.25	0.248	0.248	0.25
Wet	0.29	0.294	0.294	0.3

Source: (Appendix F. LCA IOS.pdf in U.S. Bureau of Reclamation 2023-2024)

Although Table 154 shows only small differences between water year types, this is a result of using the mean values which do not describe the variability in flows for a given water year type. Figure 160 provides a better description of the range of flows and resulting through-river-survival associated with a particular water year type. These results show wet, above normal, and below normal water year types tend to have a broad range of survivals while dry and critical year types have a much narrower range of survivals. That is to say that while modest increases in through-river-survival are expected with increasingly wet water year types, those year types also have a greater potential for more dramatic increases in through-river-survival.

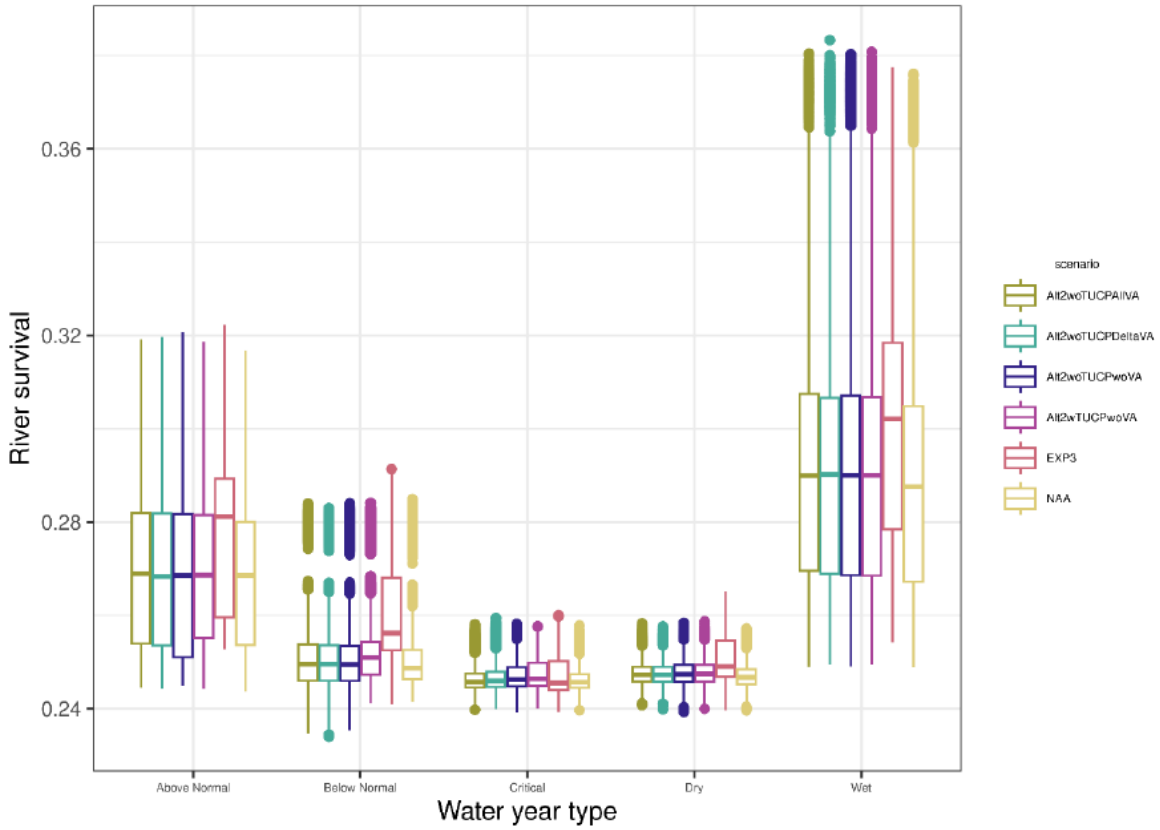


Figure 160. Boxplots showing predicted Sacramento River winter-run Chinook salmon through-river-migration survival by water year type.

Source: (Appendix F. LCA IOS.pdf in U.S. Bureau of Reclamation 2023-2024)

In the Delta, the survival of smolts is characterized by the Delta Passage Model (DPM) component, in which flow, route selection, and water exports determine survival. In the IOS model, only the timing into the Delta is altered from the standalone DPM, as spawning events and temperature are used to determine migration timing into the Delta. Once all migration groups are estimated to arrive at Chipps Island, they all enter the Ocean Survival model as a single cohort and the model begins applying mortality on an annual time step. Like the river survival model, the general trend describes an increasing survival probability for the proposed action with wetter hydrologies, where wet years have the highest predicted survival (29.4 percent) and critical years have the lowest (24.7 percent, Table 155). For context, the differences between the proposed action and NAA are small, less than a percent.

Table 155. Predicted mean Sacramento River winter-run Chinook salmon through-Delta survival by water year type.

Water Year Type	NAA	Alt2v1	Alt2v2	EXP3
Above Normal	0.31	0.311	0.315	0.36
Below Normal	0.24	0.233	0.23	0.28
Critical	0.17	0.169	0.169	0.18
Dry	0.2	0.209	0.209	0.24
Wet	0.36	0.358	0.357	0.39

Source: (Appendix F. LCA IOS in U.S. Bureau of Reclamation 2023-2024)

Ultimately, the differences in early life stage survival contribute to the annual female escapement estimates. However, the differences in female escapement based on water year type described in Table 156 do not reflect the different hydrologic conditions experienced during the out-migrating juveniles. Instead, they are a classification of the hydrology when the adults returned to spawning grounds. Therefore, the female escapement is more informative of the average effect of different operational scenarios rather than the interaction effect of hydrology and operational scenarios. For the proposed action there is no discernable pattern in female escapement and water year with the largest predicted mean survival is found in below normal years and the lowest in critical years. For context, the difference in mean SR winter-run Chinook salmon female escapement under the proposed action (Alt2v1) is 2.4 percent greater than escapement under the NAA but 42.8 percent less than the EXP3 scenario (Table 156).

Table 156. Predicted mean Sacramento River winter-run Chinook salmon female escapement by water year type.

Water Year Type	NAA	Alt2v1	Alt2v2	EXP3
Above Normal	3753	3807	3755	6241
Below Normal	3665	3821	3672	6832
Critical	2132	2136	2136	3445

Water Year Type	NAA	Alt2v1	Alt2v2	EXP3
Dry	2888	3031	2953	5448
Wet	3490	3510	3466	6518

Source: (Appendix F. LCA IOS in U.S. Bureau of Reclamation 2023-2024)

7.7.2. Oncorhynchus Bayesian Analysis

The OBAN model analysis provided by Reclamation (Appendix F. LCA OBAN in U.S. Bureau of Reclamation 2023-2024) uses statistical approaches to understand how a series of environmental drivers (e.g., temperature and flow) under management control may affect SR winter-run Chinook salmon population dynamics. The OBAN model incorporates uncertainty by estimating the influence of covariates on population abundance in a Bayesian estimation framework fitted to SR winter-run Chinook salmon escapement and juvenile counts from the 1967 to 2011 brood years. The OBAN model uses covariate values under different climate or operational alternatives provided in the CalSim and Sacramento River Water Quality Model outputs to predict patterns in SR winter-run Chinook salmon population dynamics. The modeled scenarios are used to provide inference on the relative performance of the proposed action, which is a more robust approach for evaluation compared to an absolute prediction (Fuller et al. 2008). Specifically, the OBAN model:

- Accounts for mortality during all phases of the Chinook salmon life history, including covariates with environmental and anthropogenic factors
- Evaluates covariates that may explain dynamic vital rates (e.g., thermal mortality reduces alevin survival rates in spawning reaches)
- Estimates model coefficients by fitting predictions of the population dynamics model to observed indices of abundance in a Bayesian framework

7.7.2.1. Oncorhynchus Bayesian Analysis Modeling Results

For all modeled scenarios, including the proposed action, median abundances dropped below the quasi-extinction threshold within 10 years and to a value of less than 1.0 within 14 years. The median abundance was less than 9.0 for the remainder of the time series for the proposed action, NAA, and EXP3 modeling scenarios. The pattern in abundance is due to low levels of egg-to-fry survival and Delta survival throughout the model. The median egg-to-fry survival was also less than the median historical estimated egg-to-fry survival (median = 21.2%, 95% Credible Interval [8.3%, 50.1%]) and the median Delta survival (median = 1.2%, 95% Credible Interval [0.6%, 3.4%]). The historical estimated survival rates were estimated from escapements in 1967–2011, a period of SR winter-run Chinook salmon population decline. Thus, median survival rates below the historical values would result in modeled abundance declines over the 98-year time series (Figure 161).

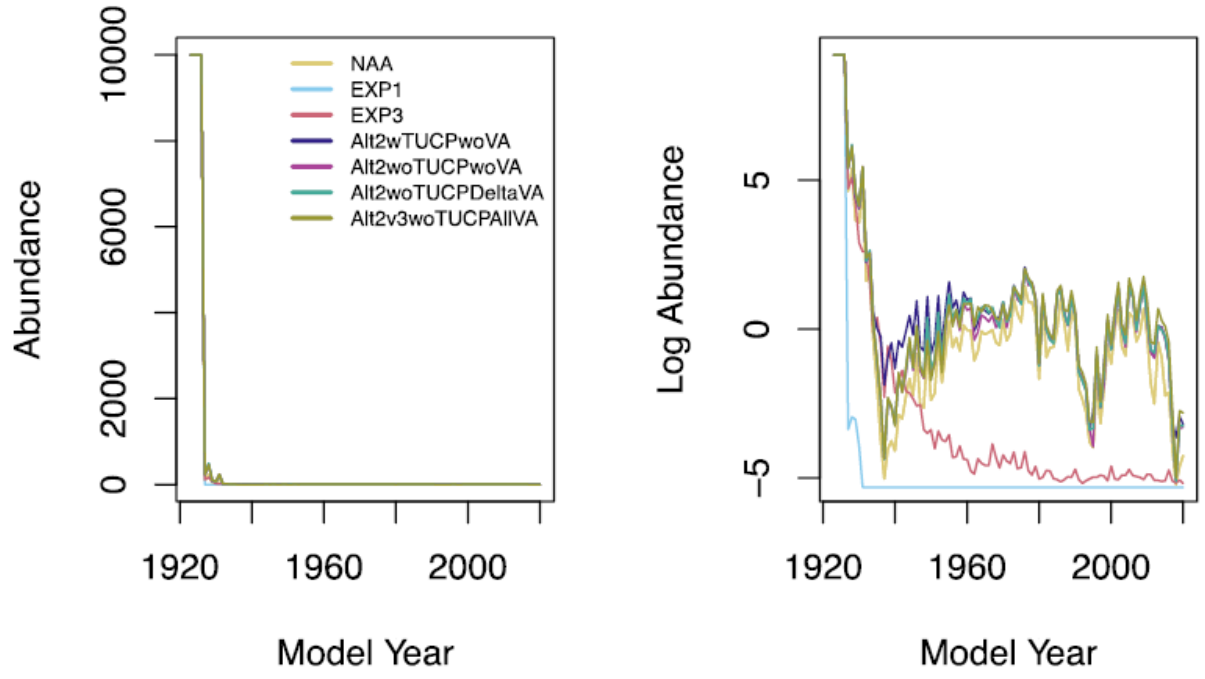


Figure 161. Median spawner abundance (left) and log abundance (right) for model years 1923–2022.

Source: (Appendix F. LCA OBAN.pdf in U.S. Bureau of Reclamation 2023-2024)

The relative abundance levels for the scenarios indicated that the proposed action and NAA are higher than EXP3. The difference in abundance levels, and the resulting modeled abundance of the proposed action, is due to the higher survival of SR winter-run Chinook salmon in the egg-to-fry stage. Egg-to-fry survival is a function of temperatures and minimum flows at Bend Bridge, the mean values of which are described in Table 157. The temperatures under the proposed action are low enough to manifest in this difference, being about a degree Fahrenheit lower than under the EXP3 scenario, but only about slightly less than a quarter of a degree lower than under the NAA. Likewise, the minimum flows in the proposed action are about 1,300 cfs higher than under the EXP3 scenario, and about 100 cfs higher than the NAA. The lower temperatures and higher Bend Bridge minimum flows result in higher egg-to-fry survival in the proposed action relative to EXP3, but similar to the NAA (Table 157).

Table 157. Mean values for physical freshwater covariates.

Component	STEMP (F)[a]	FLMIN (cfs)[b]	EXPT (cfs)[c]	YOLO (days)[d]
NAA	57.23	5469	1.275×10^6	60.64
EXP3	58.01	4256	0	71.35

Component	STEMP (F)[a]	FLMIN (cfs)[b]	EXPT (cfs)[c]	YOLO (days)[d]
Alt2v1	56.99	5574	1.312×10^6	60.84
Alt2v2	57.00	5569	1.249×10^6	60.59

F = degrees Fahrenheit; cfs = cubic feet per second.

Source: Appendix F. LCA OBAN in U.S. Bureau of Reclamation 2023-2024)

[a]STEMP: July through September mean daily water temperature in the Sacramento River at Bend Bridge. This covariate affects survival of the egg to fry life history stage.

[b]FLMIN: August through November minimum monthly flow in the Sacramento River at Bend Bridge (USGS Gauge 11377100 data). This covariate affects survival in the egg-to-fry life history stage.

[c]EXPT: Total water exports in the south Delta (CVP and SWP) during December through June, derived by taking average daily export rate, multiplying by the number of days in the month, and then summing over December-June (IEP Dayflow data). This covariate affects survival in the Delta life history stage.

[d]YOLO: Number of days during December through March with minimum flows of 100 cfs over the Fremont Weir, which is enough for positive flows onto the Yolo Bypass (December of the brood year and January – March of the year following.

Survival in the Delta stage is lower under the proposed action relative to the EXP3 scenario and similar to the NAA. Like the egg-to-fry survival, the results of Delta survival are reflected in the mean values of the physical freshwater covariates, where lower mean exports and higher Yolo Bypass days are modeled to provide greater Delta survival (Table 157). Both the proposed action and the current operations scenarios have similar export volumes and days of flooding in the Yolo Bypass, the effects of which decrease the Delta survival relative to EXP3, which reflects a scenario with no exports and therefore more days of flooding in the Yolo Bypass.

7.7.3. Central Valley Project Improvement Act Chinook Salmon Life Cycle Model

Reclamation also provided the CVPIA SIT (Science Integration Team) DSM (Appendix F_Attachment X_CVPIA Winter-Run and Spring-Run LCMs.pdf in U.S. Bureau of Reclamation 2023-2024), which were developed by the CVPIA SIT as part of a structured decision-making process. The resulting DSMs are open source, publicly available,[22] and published in a peer-reviewed publication (Peterson and Duarte 2020). The DSMs are stochastic or deterministic stage-based life cycle models that track the number of Chinook salmon across juvenile size classes and adult stages of natural and hatchery origin. The transitions between stages are estimated with survival, growth, and movement submodels. Model inputs include existing habitat areas, fish harvest rates, water diversions, flows, and temperatures. Flow information was obtained from CalSim 3 outputs which required a model conversion from CalSim II (CalSim II

[22] https://cvpia.scienceintegrationteam.com/cvpia-sit/resources/dsm-r-packages

to CalSim 3 Conversion – CVPIA SIT LCM.docx in U.S. Bureau of Reclamation 2023-2024). Temperature data are primarily obtained from HEC-5Q outputs, but where HEC-5Q data were unavailable, temperatures are modeled based on measured water temperatures, statistical models relating water temperature to air temperature, or matching of tributaries with similar hydrology and geomorphology. Habitat inputs are primarily based on previously published flow-habitat relationships. Where flow-habitat relationship information is not available, relationships are assumed to be similar to those of nearby, geomorphically similar watersheds. All other inputs, except for predator prevalence, are obtained from previously published sources. Ultimately, the models are parameterized and calibrated using a combination of empirical data, existing models, analysis of existing data, and expert opinion. In interpreting the CVPIA SIT DSM results, it is important to understand that the model is not constructed to vary as a function of scenario-dependent flow and temperature values, such that egg-to-fry survival is constant across scenarios. Instead, the models are largely dependent on the habitat values and flow-habitat relationships, which provide limited opportunity for interpretation of results.

7.7.3.1. Central Valley Project Improvement Act Winter-Run Life Cycle Model Results

Predicted total and natural-origin-only spawner abundances in the Upper Sacramento River for the deterministic model runs generally peak in 1986, decrease steadily until 1994, and then increase steadily through 1999 for the proposed action (Figure 162). The difference between the proposed action, NAA, and EXP3 scenarios for natural-origin-only spawner abundances at the end of the time series was very small, with the proposed action having a final abundance of 5,471, the NAA having a final abundance of 5,558, and the EXP3 having a final abundance of 5,467. Over the entire time series, predicted natural-origin-spawner abundances for the proposed action ranged from 1,575 to 14,542 (Alt2v1), while they range from 2,390 to 14,497 for the NAA, and 2,791 to 13,808 for EXP3.

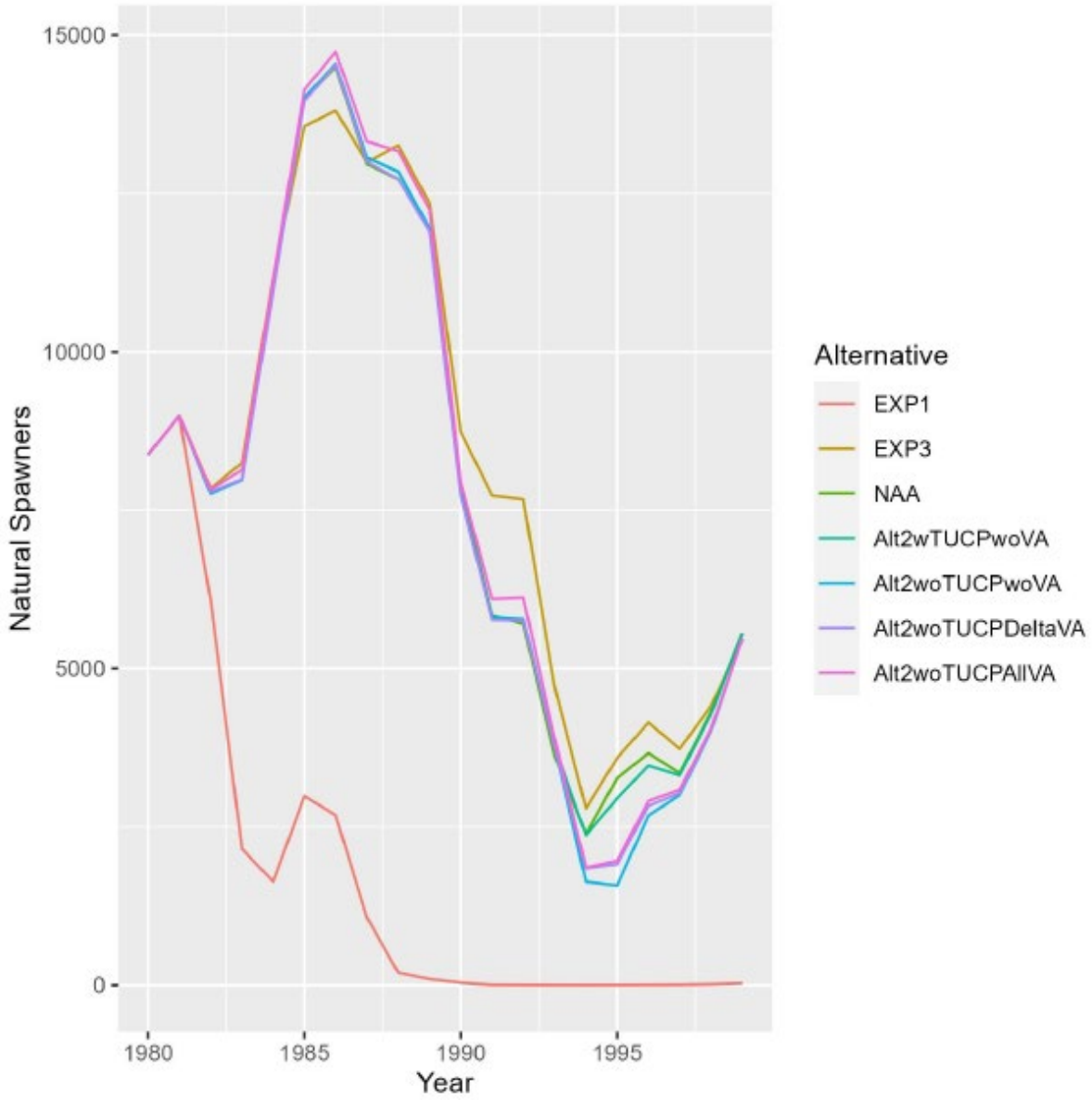


Figure 162. Expected annual abundances of natural-origin Sacramento River winter-run Chinook salmon spawners in the Upper Sacramento River from deterministic model runs.

Source: (Appendix F_Attachment X - CVPIA Winter-Run LCM.pdf in U.S. Bureau of Reclamation 2023-2024)

For deterministic model runs, population change over time, defined by mean (i.e., geometric) lambda values (Nt+1/Nt) over the entire 1980–1999 time series, ranged from only 97.9 percent to 98.0 percent, and terminal lambda values (Nt=19/Nt=1) were 66.9 percent (Alt2v1), 67.9 percent (NAA), and 66.8 percent (EXP3). These values indicate that predicted spawner abundances for all scenarios declined over the course of the time series and that the current operations scenario (NAA) showed the least decline. Table 158 shows that across all scenarios, wet water years have the highest mean annual lambdas (greater than 1.1 for both scenarios), and dry water years also have a mean annual lambda greater than 1, indicating that the population grew in both wet and

dry years (Table 158). Mean lambdas are less than 1 in critical and above normal water years, indicating that in those year types the population declined.

Table 158. Predicted mean lambda (Nt+1/Nt) for total Sacramento River winter-run Chinook salmon spawner abundance in the Upper Sacramento River, including both natural- and hatchery-origin fish, from deterministic model runs.

Water Year Type	NAA	Alt2v1	Alt2v2	EXP3
Critical	0.815	0.778	0.787	0.848
Dry	1.042	1.041	1.042	1.038
Above Normal	0.659	0.672	0.677	0.633
Wet	1.129	1.174	1.155	1.108
All	0.980	0.979	0.979	0.979

Source: (Appendix F_Attachment X - CVPIA Winter-Run LCM in U.S. Bureau of Reclamation 2023-2024)

Because the DSM is not constructed to vary as a function of the scenario-dependent flow and temperature values, the egg-to-fry survival is constant across the modeled scenarios. Deterministic model runs for all scenarios show that the monthly rearing survival for small juveniles (i.e., less than 42 millimeters) in the Upper Sacramento River varied from a low of approximately 1 percent to a high of approximately 20 percent; rearing survival also varied across months, peaking in November and December (Figure 163). Model-estimated migratory survival for very large fish (i.e., smolt size; greater than 110 millimeters) in the Upper-mid, Lower-mid, and Lower Sacramento River was consistently close to 1, with slight variations across months and water year types. In the Upper-mid and Lower-mid Sacramento River, expected survival is lower in May than in other migratory months, but no such patterns are observed in the Lower Sacramento River. Although the modeled operational scenarios appear to have a minimal influence on migratory survival for very large fish, survival does vary across months and water year types in the North and South Delta. Migratory survival often increases with wetter water year classifications, and the expected migratory survival is greatest in February and March (84.7 percent to 86.0 percent) and lowest in September, October, and May (80.9 percent to 84.8 percent). With migratory survival in the North Delta high for all modeled scenarios, and because the model was not constructed to consider the influence on egg-to-fry survival of changes in temperature and flow, rearing survival and migratory survival in the South Delta likely act as the primary drivers of the observed differences in lambda.

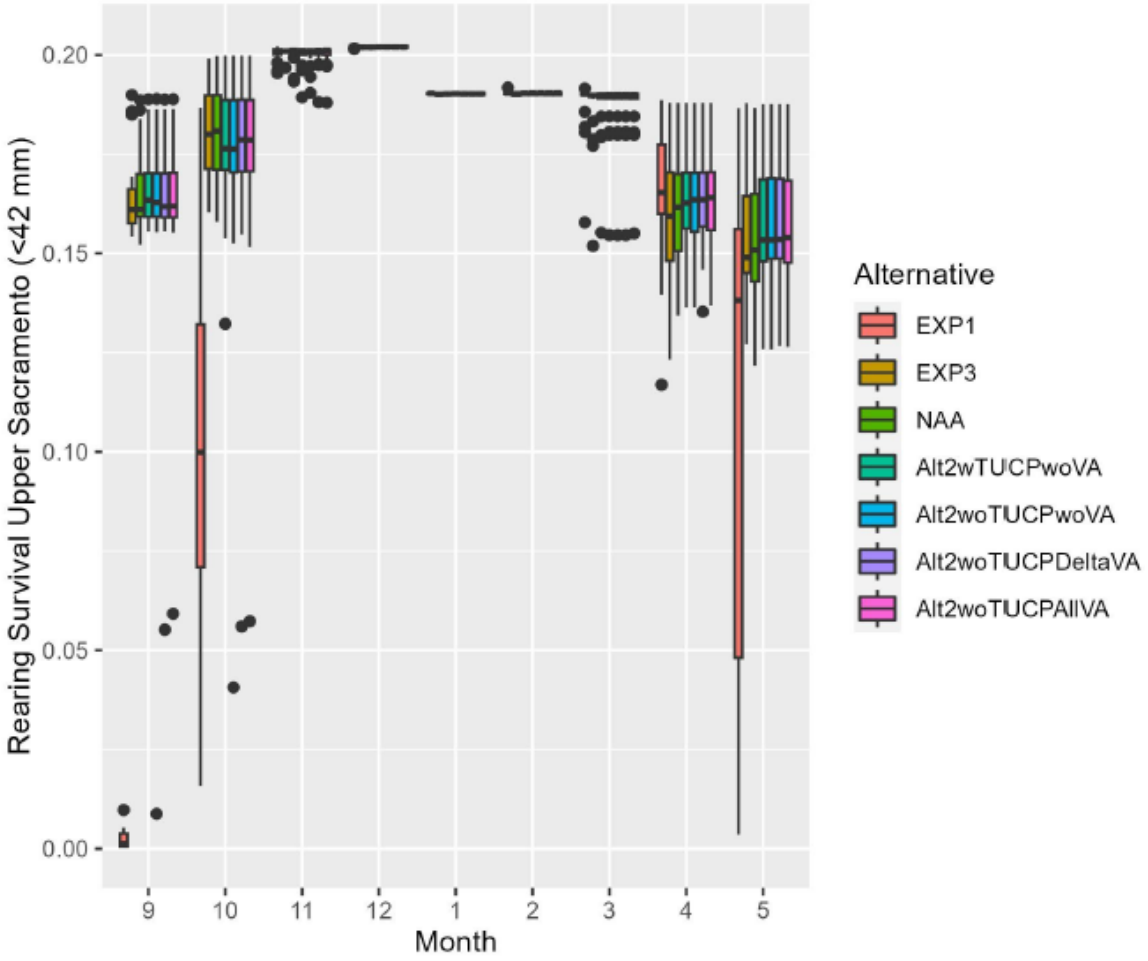


Figure 163. Predicted small juvenile rearing survival for Sacramento River winter-run Chinook salmon in the Upper Sacramento River from deterministic model runs across the 20-year time series.

Source: (Appendix F_Attachment X - CVPIA Winter-Run LCM inU.S. Bureau of Reclamation 2023-2024)

7.7.3.2. Central Valley Project Improvement Act Spring-Run Life Cycle Model Results

The predicted total and natural-origin-only CV spring-run Chinook salmon spawner abundances in the Central Valley for the deterministic model runs fluctuated between 1980 and 1999. The combined populations in the Upper Sacramento River reached a low in the early 1980s, peaked in 1988, decreased steadily until 1990, and then trended upward until 1999 (Figure 164 and Figure 165). The Clear Creek population's natural spawner abundance peaked in 1980 and reached a low in 1990 (Figure 164). The proposed action (Alt2v1) has a slightly lower natural-origin-only spawner abundance at the end of the time series relative to the EXP3 scenario, while the abundances are similar between the proposed action and the NAA.

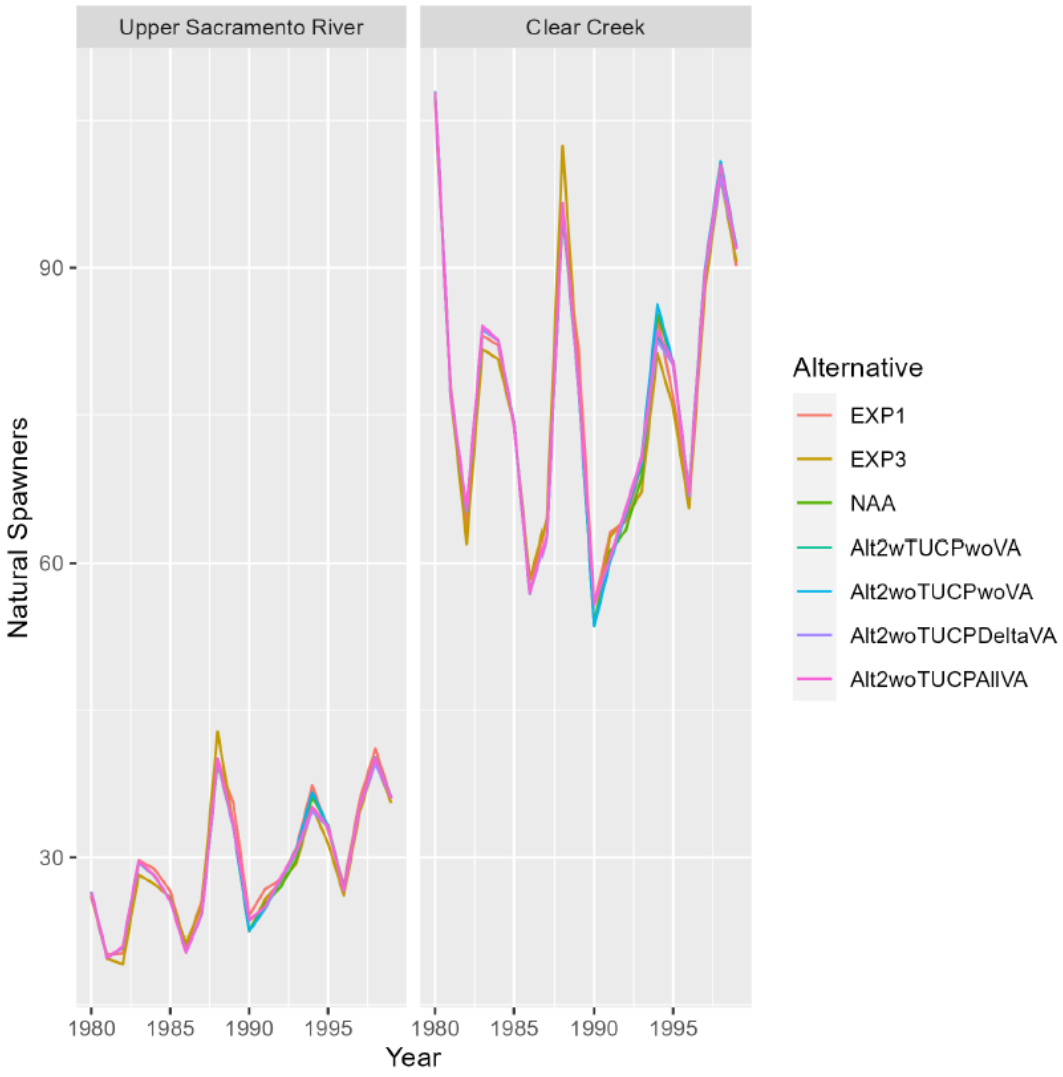


Figure 164. Expected annual abundances of natural-origin Central Valley spring-run Chinook salmon spawners in the Upper Sacramento River and Clear Creek from deterministic model runs.

Source: (Appendix F_Attachment X - CVPIA Spring-Run LCM in U.S. Bureau of Reclamation 2023-2024)

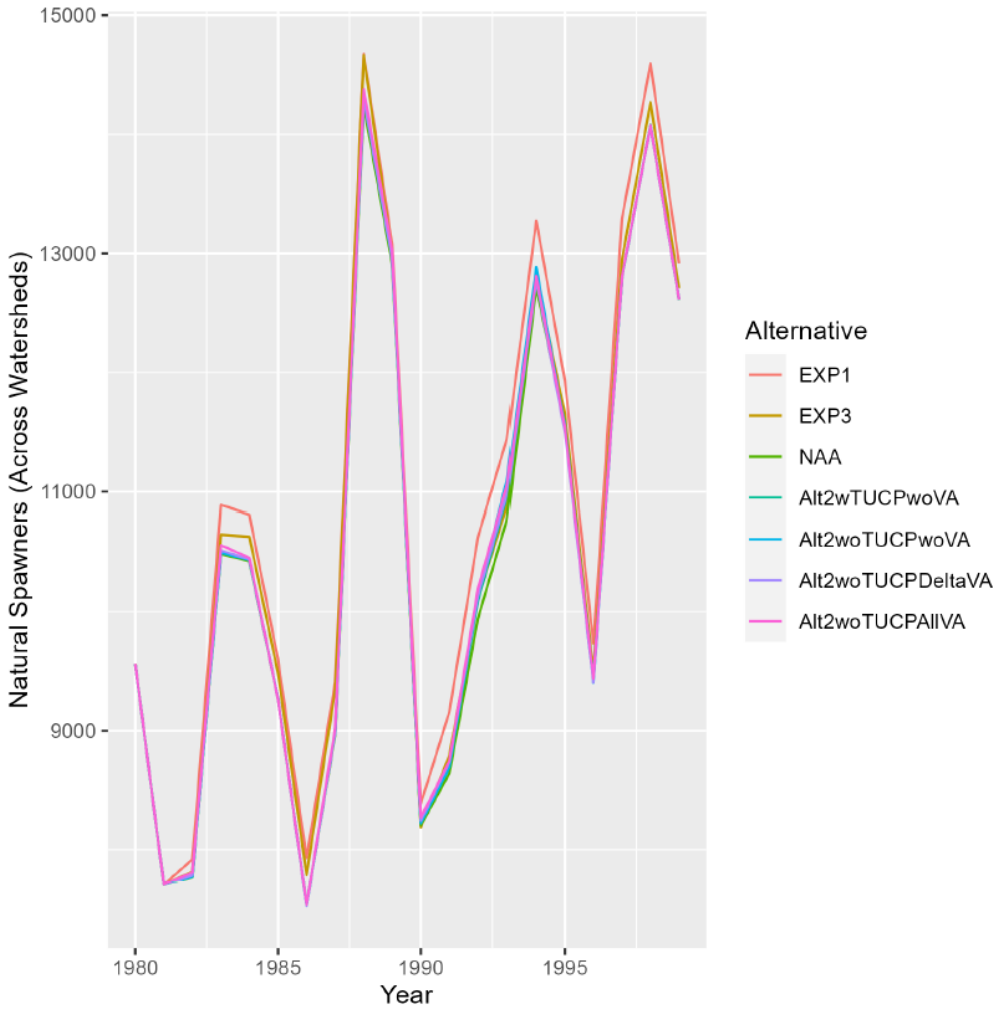


Figure 165. Expected annual abundances of natural-origin Central Valley spring-run Chinook salmon spawners in the Central Valley from deterministic model runs.

Source: (Appendix F_Attachment X - CVPIA Spring-Run LCM in U.S. Bureau of Reclamation 2023-2024)

For the deterministic model runs, population change over time, defined by mean (i.e., geometric) lambda values (Nt+1/Nt) over the entire 1980–1999 time series and all water year types, is 1.01. Likewise, terminal lambda values (Nt=19/Nt=1) are 1.205 for the proposed action (Alt2v1) current operations (NAA), and EXP3 scenarios. These values indicate that predicted spawner abundance increased over the course of the time series. Under deterministic models, critical water years have the highest mean annual lambda (>1.07), and above normal and wet water years also have a mean annual lambda greater than 1, indicating that the population grew in both wetter and drier conditions. Under dry water year types, the mean lambda is less than 1, indicating declining populations.

Across the deterministic runs, monthly rearing survival for small juveniles (i.e., less than 42 millimeters) in the Upper Sacramento River varies from a low of approximately 1.6 percent to a high of approximately 2.4 percent. Rearing survival in the Upper Sacramento River also varies

across months, peaking in December and January, and shows greater variation across water years in April and May. In Clear Creek, monthly rearing survival for small juveniles (i.e., less than 42 millimeters) also varies across deterministic runs from approximately 12 percent to 18 percent, as well as across months, with greater survival from February to May and lower survival from November to January.

The model-estimated migratory survival for very large fish (i.e., smolt size; greater than 110 millimeters) in the Upper-mid, Lower-mid, and Lower Sacramento River is close to 1, with slight variations across months and water year types. In the Upper-mid, Lower-mid, and Lower Sacramento River, the expected survival is consistently highest in wet years. Migratory survival rates in the North and South Delta also vary across months and water year types for very large fish, with migratory survival increasing with increasingly wetter water year types. In the North Delta, migratory survival is high, ranging from 89.4 percent to 93.5 percent, while the South Delta ranges from 20.5 percent to 57.6 percent. In the South Delta, expected migratory survival is greatest in February and March (46.7 percent to 50.5 percent across all water year types) and lowest in November (30.1 percent to 33.3 percent across all water year types). With high migratory survival in the mainstem Sacramento River and North Delta in all scenarios, and because the model was not constructed to consider the influence on egg-to-fry survival of changes in temperature and flow, rearing survival and migratory survival in the South Delta likely act as drivers of differences in lambda.

7.7.4. Southwest Fisheries Science Center's Sacramento River Winter-Run Chinook Salmon Life Cycle Model

The WRLCM is a state-space life cycle model for SR winter-run Chinook salmon in the Sacramento River developed by the SWFSC (Hendrix et al. 2024). This model was used to analyze the proposed action (Alt2v1) relative to the current operations scenario (NAA). The WRLCM looks at multiple life cycle stages, including eggs, fry, smolts, juveniles in the ocean, and mature adults in the spawning grounds. The model is spatially explicit and includes density-dependent movement among habitats during the fry rearing stage. It also incorporates survival from the habitat of smolt origin to Chipps Island by applying one of a number of possible Smolt Survival Models (SSM). For the LTO consultation application of the WRLCM, the ePTM (Sridharan et al. 2023) was used for the SSM. The WRLCM operates at a monthly time step in the freshwater stages and at an annual time step in the ocean stages. Parameter estimates for the model were obtained from external analyses, expert opinion, and estimation by statistical fitting to observed data. The observed data included SR winter-run Chinook salmon natural-origin escapement, juvenile abundance estimates at Red Bluff Diversion Dam, and juvenile abundance estimates at Chipps Island. To evaluate alternative management actions, 1,000 Monte Carlo parameter sets were run that incorporated parameter uncertainty, process noise, and parameter correlation.

The proposed action scenario (Alt2v1) and the NAA were run for each of the 1,000 parameter sets, and considered relative to one another. These scenarios should be evaluated in a relative sense when using the WRLCM because relative comparisons are more robust than the absolute predictions from the WRLCM (Fuller et al. 2008). Moreover, it would be incorrect to equate outputs of the model as actual numbers of fish in the Sacramento River. This perspective is adopted for several reasons: (1) the underlying hydrology of the scenarios is based on CalSim 3

model outputs that are a combination of historical hydrology and future expected hydrologic conditions, but do not represent actual historic or future hydrology; (2) the WRLCM model and the models used to provide input to the WRLCM that use the CalSim 3 results (HEC-RAS, DSM2, and ePTM), like all models, require assumptions that simplify physical phenomena; and (3) the WRLCM was not calibrated to produce forecasts of actual abundances. As a result, the WRLCM is viewed as a tool that can provide guidance on the relative performance of a set of operations, and the percent difference (e.g., [proposed action – NAA]/NAA x 100) is computed for each of the 1,000 model runs. A detailed description of the model methods and assumptions is contained in the NOAA Technical Memorandum describing the WRLCM modeling framework (Hendrix et al. 2024).

The model was applied to all scenarios using an initial abundance of 10,000 spawning adults as a representative population of SR winter-run Chinook salmon. This initial abundance is not meant to reflect current, historical, or projected population trends, but instead is used to seed the model. The standard hydrology used in this evaluation represents the 100-year historical CalSim 3 record from 1922 to 2021. However, prior to 1926, the WRLCM is initializing; results from these years may disproportionately reflect the initial conditions. To control for this potential artificial skew in results, only annual percent differences from the 1926 abundance value (which may differ slightly between the scenarios due to the initialization period) and afterward are used to calculate the abundance and CRR metrics.

7.7.4.1. Sacramento River Winter-Run Chinook Salmon Life Cycle Model Results

Overall, the WRLCM results indicate higher abundances and higher CRR for the proposed action (Alt2v1) scenario relative to the NAA. Mean abundance is 37.12 percent more for the proposed action scenario relative to the NAA (Table 159, Figure 166). The probability that the average abundance for the proposed action would be greater than the average abundance for the NAA in the 100-year time series is 1.00. That is, of the 1,000 paired runs of the NAA and the proposed action scenario, all had an average modeled abundance for the proposed action that was greater than the average modeled abundance for the NAA, leading to a probability of 1.00.

Table 159. Mean of percent change in annual abundance (sum of in-river, natural, and hatchery-origin spawners) averaged across all years. Pr(Alt>NAA) is the probability that a realization of the alternative scenario will have a positive percent change averaged across all years.

Scenario	Mean % Change in Abundance	95% CI	Pr(Alt>NAA)
Alt2v1	37.12	[36.05, 38.2]	1.00
Alt2v2	41.65	[40.32, 42.97]	1.00
EXP3	294.16	[276.19, 312.14]	1.00

Source: WRLCM Report, multi-scenario LTO DRAFT NAA Baseline Hatchery Integrated, May 7, 2024 (QEDA Consulting LLC 2024)

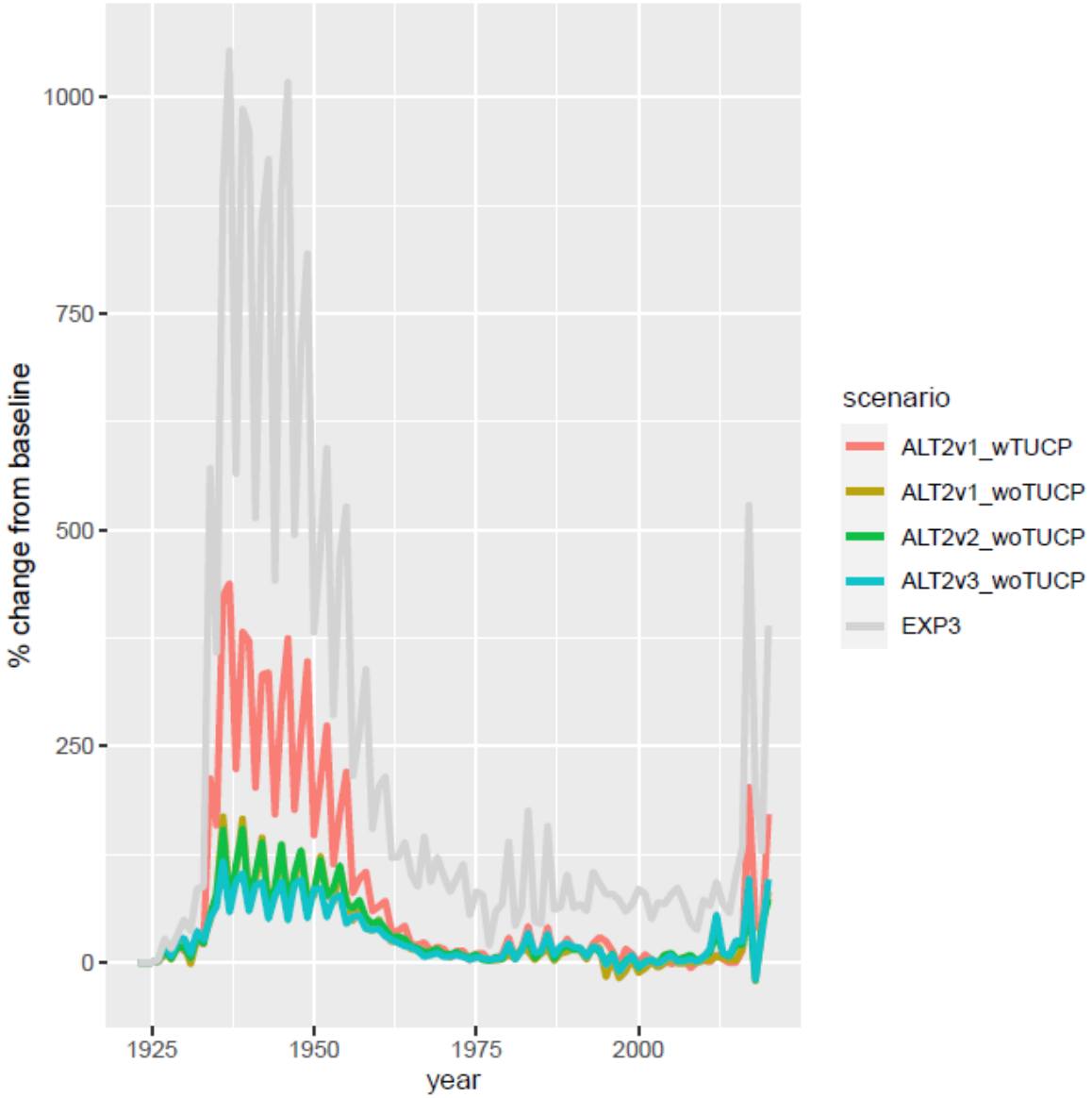


Figure 166. Percent change in annual escapement.

Source: WRLCM Report, multi-scenario LTO DRAFT NAA Baseline Hatchery Integrated, May 7, 2024 (QEDA Consulting LLC 2024)

The CRR is a key metric to understand population dynamics, since it characterizes the ability of a population to replace itself. In the model runs, estimates of the difference in CRR for 1,000 paired runs of the WRLCM indicate that there is a 1.00 probability that the CRR would be higher for the proposed action scenario relative to the NAA over the 100-year model period. There is a consistent difference over the model period because density dependence in the spawning stages will cause the CRR to decrease for situations with higher spawner abundance. In the WRLCM,

the spawner density-dependence relationship is a Beverton-Holt function where density-dependent effects begin to occur at spawner abundances below the carrying capacity. This density-dependent function directly influences the production of eggs in the model such that when the spawner abundance is above approximately half the carrying capacity, the production of eggs per spawner will start to decrease as abundance increases. The loss of productivity from a decrease in the maximum eggs per spawner affects the CRR negatively, leading to reduced CRR at higher abundances. Furthermore, the mean percent change in CRR for the proposed action scenario is 1.60 percent more than the mean CRR of the NAA modeling scenario (Table 160). This number indicates that the population's ability to replace itself is, numerically, increased for the proposed action scenario over the 98-year timeseries. The relatively small increase in the mean percent change in proposed action CRR relative to the NAA is partially driven by the increase in abundance causing a decrease in the production of eggs per spawner, and because of the similarities between the NAA and the proposed action scenario.

Table 160. Mean of percent change in cohort replacement rate (CRR) averaged across all years. Pr(Alt>NAA) is the probability that a realization of the alternative scenario will have a positive percent change averaged across all years.

Scenario	Mean % Change in CRR	95% CI	Pr(Alt>NAA)
Alt2v1	1.60	[1.54, 1.65]	1.00
Alt2v2	1.46	[1.4, 1.52]	0.99
EXP3	25.47	[24.98, 25.96]	1.00

Source: WRLCM Report, multi-scenario LTO DRAFT NAA Baseline Hatchery Integrated, May 7, 2024 (QEDA Consulting LLC 2024)

The WRLCM is also able to describe the influence of hatchery operations at the Livingston Stone National Fish Hatchery and how hatchery production of SR winter-run Chinook salmon may interact with a particular water operation scenario. Specifically, the model is able to identify what proportion of the spawning population is natural vs hatchery origin. The term pHOS or percent of hatchery fish naturally spawning in the river is used to understand the degree to which the mixed hatchery and natural origin population relied on the hatchery population to contribute to escapement and spawning abundance. Figure 167 plots the range of maximum pHOS values (max of the 98-year timeseries) for each of the 1000 iterations of the WRLCM under each modeled scenario to provide a sense of the degree to which the hatchery origin population influenced the diversity of the mixed hatchery and natural origin population. Because hatchery operations are relatively stable, averaging 245 adult fish collected over each of the last ten years, changes in pHOS tend to reflect population dynamics of the natural origin population. Relative

to the NAA the proposed action results in less dependence on the hatchery origin spawners (i.e. smaller pHOS).

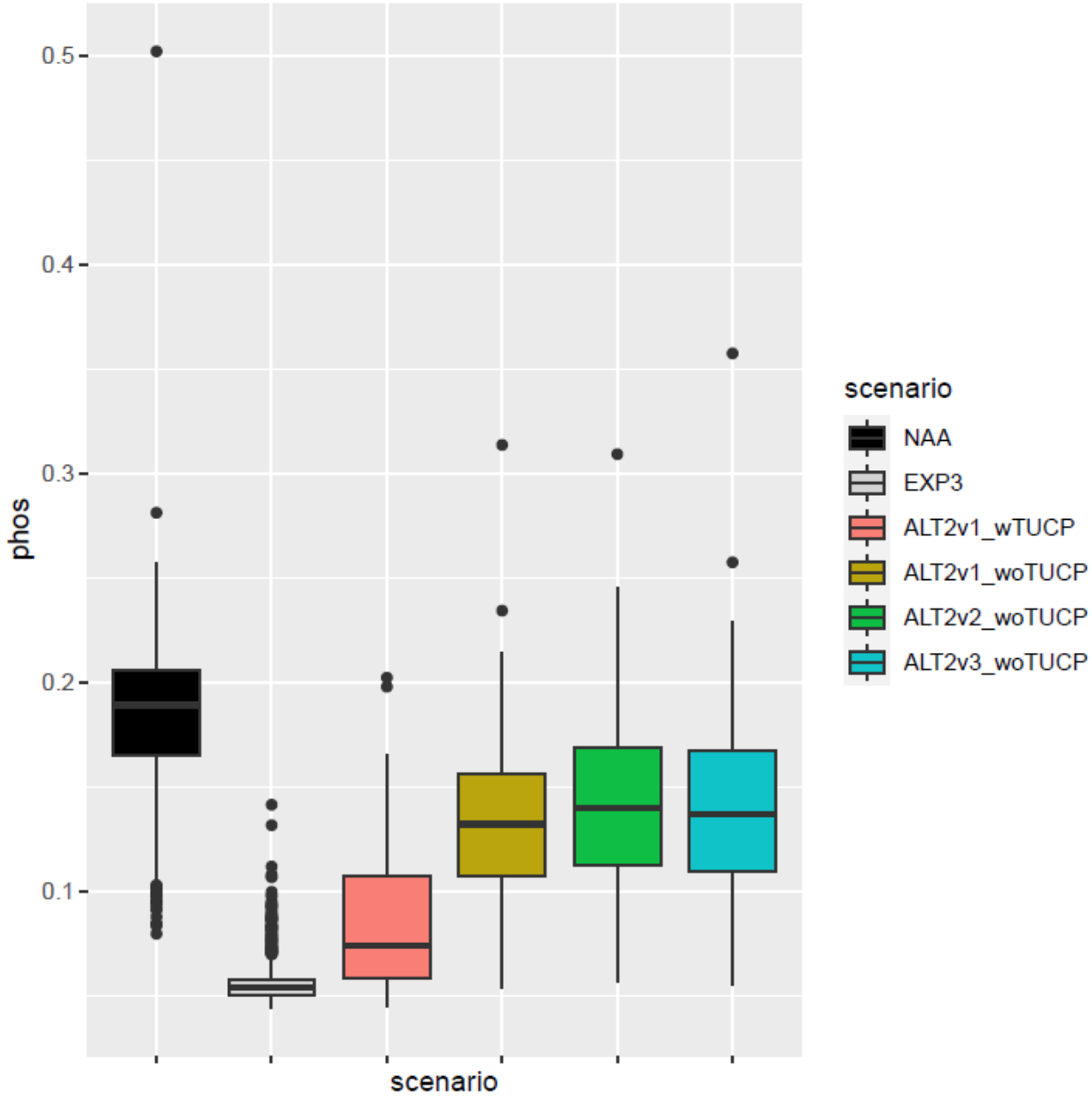


Figure 167. Maximum pHOS values for each of the 1000 iterations of the WRLCM under each scenario.

Source: WRLCM Report, multi-scenario LTO DRAFT NAA Baseline Hatchery Integrated, May 07, 2024 (QEDA Consulting LLC 2024)

7.7.5. Summary of Life Cycle Model Conclusions

Overall, many of the models indicated a similar direction of effect, if not magnitude of effect. Specifically, for the IOS model and the SWFSC's WRLCM, proposed action results relative to

the NAA scenario, showed little difference in egg and fry survival for most year types except critical water years where SR winter-run Chinook salmon egg and fry survival were similar to but averaged higher under the proposed action compared to the NAA. The IOS modeling also showed that across all year types estimated through-Delta survival shows little difference under the proposed action modeling scenario relative to the NAA modeling scenario. Ultimately, the IOS predicted that the mean SR winter-run Chinook salmon female escapement by water year type showed slightly higher female escapement under the proposed action scenario relative to the NAA modeling scenario. Likewise, the WRLCM showed that, relative to the NAA modeling scenario, the proposed action modeling scenario resulted in a mean percent change in CRR of about 13 percent more than the percent change in CRR of the NAA scenario.

By comparison, the CVPIA SIT DSM and OBAN life cycle model described only small differences between modeled scenarios, however, all described a declining SR winter-run Chinook salmon population. The OBAN model showed that, for all scenarios considered, the median abundances dropped to below the quasi-extinction threshold within 10 years and to a value of less than 1.0 within 14 years. Similarly, the CVPIA SIT model indicated that all scenarios produced declining abundance over the 19-year time series (1980–1999), where the final population was about 67 percent of the original seed population. For both models, the relative lack of sensitivity to the operational differences of the proposed action and obligated release scenarios is not entirely unexpected. The OBAN model was calibrated from the historical survival rates, estimated from escapements in 1967–2011, which was a period of SR winter-run Chinook salmon population decline. The observed pattern in abundance decline across the OBAN modeled scenarios is due to levels of egg-to-fry survival and Delta survival below those historical levels. Thus, median survival rates that are below the historical values result in modeled abundance declines over the 98-year time series, which also preponderates the effects of operational differences between the scenarios. Likewise, the CVPIA SIT DSM is not constructed to vary as a function of scenario-dependent flow and temperature values, such that egg-to-fry survival is constant across the modeled scenarios, resulting in very small differences in viability metrics across scenarios.

7.8. Other Activities

Other Activities include action components that are not specifically proposed by Reclamation but would not occur but for the action and that are reasonably certain to occur. These kinds of activities were previously referred to as “interrelated or interdependent” activities. Under the 2019 ESA regulations governing interagency coordination, a proposed action may cause other associated or connected actions, that are now called “other activities” to distinguish them from the proposed federal action. These activities and their consequences must pass a two-part test of causation and foreseeability, meaning that they would not happen “but for” a federally proposed action and that they are “reasonably certain to occur.”

Portions of the WRAP meet the two-part test of “but for” and “reasonably certain to occur” for the following reasons: First, the WRAP is a result of agency discussions with the SRSCs for the operations of Shasta Reservoir. Without the new Shasta Operations framework, elements of the WRAP would not have been proposed; thus, it meets the “but for” standard. Next, the elements of the WRAP are reasonably certain to occur because the parties to the WRAP have a long history, either individually or together, of advancing science, implementing habitat restoration,

reintroducing fish to historic habitats, improving system infrastructure, and adaptively managing hatcheries for long-term species needs.

This WRAP was developed collaboratively among representatives from Reclamation, NMFS, USFWS, DWR, CDFW, and the SRSCs as an integrated plan to improve the survival and viability of SR winter-run Chinook salmon that functions alongside the planned operation of Shasta Reservoir. The WRAP is specifically connected to SR winter-run Chinook salmon through the Shasta Framework as a mechanism to improve the overall viability of the ESU. The WRAP was not developed to address conservation concerns of other species, although it may serve as a useful partnership to model. The WRAP includes a list of six high-priority actions to reduce the stressors to SR winter-run Chinook salmon through a combination of science, fishery actions, infrastructure improvements, and reintroduction to historic habitat. The plan priorities include:

1. Thiamine Deficiency Complex Management
2. Reintroduction into Battle Creek and McCloud River
3. Early Life Stage Survival Science
4. Temperature Control Device Infrastructure Improvement at Shasta Dam
5. Modernization of the Livingston Stone National Fish Hatchery
6. Habitat restoration and facility improvements

The broad goals of the WRAP are to:

- Develop a structured and collaborative partnership that includes state and federal agencies (Reclamation, NMFS, USFWS, DWR, and CDFW), the SRSCs, non-governmental conservation and fishery groups, tribes, and universities.
- Elevate the prominence of priority actions, in addition to operations of Shasta Dam, that are expected to enhance our understanding of SR winter-run Chinook salmon ecology, address key threats to the species, and move forward key infrastructure improvements to support the species.
- Increase abundance, improve population growth rates, maximize diversity, improve resiliency, and prevent extinction of SR winter-run Chinook salmon through the implementation of identified actions.
- Collaboratively assess funding needs to implement each of the priority actions, identify available funding sources, and pursue additional funding sources, as needed.
- Work together at a technical and project management level to develop plans and implement each priority action, meet the established milestones, and provide timely deliverables.
- Identify resource needs to actively engage and make progress on each identified action according to milestones.
- Communicate early about permitting needs anticipated for each priority action and coordinate throughout permitting processes.
- Consider links and potential co-benefits to other Chinook salmon runs, as well as other native fishes, during the process to plan and implement priority actions.

Under the WRAP, agencies and partners will dedicate managers from each organization to participate on a WRAP policy team that will coordinate plan implementation. The purpose of the policy team is to establish policy-level coordination and processes for tracking plan goals,

priorities, funding, resource needs, milestones and deliverables. The policy team will work closely with a science facilitator and a program manager to track and meet the various milestones in the plan. The WRAP recognizes that some action plan components may be part of separate planning processes, and the policy team will evaluate opportunities to utilize existing efforts.

Each priority action plan includes a list of target actions and milestones as well as a description of next steps for permitting and authorization. It is expected that each of the actions will be permitted independently from the proposed action for water operations, but the WRAP will build on the efficient and effective collaborative decision-making framework of Governance to make timely and accountable progress on the implementation of these actions to improve the viability of the ESU.

Implementation of the WRAP would occur over the next 10 years and focus on individuals in the Upper Sacramento River near Redding, California. The Thiamine treatment, early life stage science, and reintroduction action elements would expose adult and juvenile SR winter-run Chinook salmon to capture and handling, and in some cases, they may respond to sublethal or lethal effects. More beneficial responses are also expected, with anticipated improvements in early life stage survival, reproductive success, and resilience from catastrophic events such as thiamine deficiency and drought.

7.9. Programmatic Analysis

As described in the Analytical Approach section, this opinion is considered a "mixed programmatic" action, and includes certain action components being analyzed as programmatic actions. Programmatic actions include framework programmatic actions that establish a framework for the development of future actions that are authorized, funded, or carried out at a later time, and any take of a listed species would not occur unless and until those future actions are authorized, funded, or carried out and subject to further ESA section 7 consultation.

The level of detail available at the framework programmatic level is often insufficient to identify with particularity where, when, and how the program will affect listed species. Without such detail, it is difficult to identify the amount or extent of take associated with the specific program and write sufficiently specific and meaningful terms and conditions intended to minimize the impact of the taking for the benefit of the listed species. Under a framework programmatic approach, as specific projects are developed in the future, they are subject to project-specific stepped-down, or tiered, consultations where incidental take is addressed. Once framework-level action components are further developed with sufficient detail to determine the amount or extent of incidental take, they will require additional ESA section 7 consultation before implementation; this subsequent consultation will include an incidental take statement for those components. The implementation of specific actions depends on the circumstances and severity of drought conditions, and would occur after the future consultations are complete.

Framework programmatic actions are often described in more broad terms, and receive a qualitative analysis of their potential effects on listed species and critical habitat. In some cases, programmatic actions are designed to a level of detail where the action and its effects are reasonably certain to occur and can be analyzed more quantitatively. Regardless of whether an action is analyzed qualitatively or quantitatively, NMFS applies the same approach regarding the

potential species exposure, response, and risk to individuals and populations described in this opinion's Analytical Approach section.

The following framework programmatic actions are considered in this opinion:

- The Sites Reservoir Project
- The Delta Conveyance Project
- Spring Outflow: Post-Adoption of VAs
- Drought Response (i.e., Drought Toolkit)
- Monitoring
- Tidal Habitat Restoration
- Adaptive Management and Special Studies

Reclamation will not implement framework programmatic actions prior to ensuring that ESA section 7(d) is adhered to by completing project-specific ESA section 7 consultations prior to implementing project operations.

7.9.1. Sites Reservoir Project and Delta Conveyance Project

The Sites Reservoir Project (Sites) and the Delta Conveyance Project (DCP) are framework programmatic actions in this consultation. The proposed action includes qualitative descriptions of Sites and DCP, and the BA's (U.S. Bureau of Reclamation 2023-2024)effects analysis describes the potential operational effects for both Sites and DCP individually and combined. The purpose of the framework programmatic approach is to assess how these projects would operate in the context of the LTO proposed action by broadly assessing the impacts of the operations of these projects. This framework programmatic analysis considers the potential pathways for the operation of Sites and DCP facilities to affect LTO operations of the CVP and SWP (i.e., the proposed action). The analysis considers the potential impacts to stressors that are influenced by storage in upstream reservoirs, changes in flows and temperatures upstream of Sites and DCP, changes in flows adjacent to Sites and DCP facilities, and changes in flows and hydrodynamics through and downstream of the Delta, that affect listed species and their critical habitat. Specifically, both Sites and DCP will require project-specific ESA consultations that are expected to be initiated shortly after the completion of the LTO consultation. This approach is also consistent with the AMP of the LTO of the CVP and SWP where the study and subsequent consultation on the framework programmatic elements of the proposed action would be considered "bin 3" actions (AMP appendix B in U.S. Bureau of Reclamation 2023-2024).

7.9.1.1. Sites Reservoir Project

Sites would use existing infrastructure to divert unregulated and unappropriated flow from the Sacramento River at Red Bluff and Hamilton City and convey the water to a new offstream reservoir west of the community of Maxwell, California. New and existing facilities would move water into and out of the reservoir. Releases from Sites Reservoir would be used locally, conveyed to the Yolo Bypass for ecosystem benefits, or ultimately returned to the Sacramento River system via existing canals and a new pipeline located near Dunnigan, California.

Reclamation's role in Sites is as a funding partner. Reclamation would acquire a water storage account in Sites Reservoir and an additional water supply it may use to supplement its existing supplies. Reclamation's purposes for the project include the following:

- Increased water supply and improved reliability of water deliveries
- Increased CVP operational flexibility
- Benefits to anadromous fish by improving CVP operations consistent with the laws, regulations, and requirements in effect at the time of operation
- Incremental Level 4 water supply for CVPIA refuges
- Delta ecosystem enhancement by providing water to convey food resources

7.9.1.2. Delta Conveyance Project

The DCP includes the construction and operation of new water intake facilities on the Sacramento River in the North Delta and a single main tunnel to divert and move water entering the North Delta from the Sacramento Valley watershed to existing SWP facilities in the South Delta, which would result in a dual conveyance system for the SWP in the Delta (see Table 3-17 for additional details on operations of the proposed project [Public Draft Environmental Impact Report Alternative 5, Bethany Reservoir Alignment]). DWR is not seeking to increase its existing water rights, nor is it proposing any operational changes upstream of the Delta. The DCP, if approved, would be a part of the SWP's integrated water delivery system and, therefore, would be considered within the LTO of the CVP and SWP. DWR would implement "dual conveyance" by operating the proposed North Delta diversion in conjunction with the existing South Delta diversion system for the SWP. During the winter and spring, operations of existing South Delta water export facilities would be prioritized up to what is permitted under the existing water rights and all applicable state and federal laws and regulations before operating the proposed North Delta intakes.

DWR's fundamental purpose in proposing the DCP is to develop new intake and conveyance facilities in the Delta to restore and protect the reliability of SWP water deliveries, and potentially CVP water deliveries, south of the Delta, consistent with the State's Water Resilience Portfolio and in a cost-effective manner. The DCP includes the following objectives:

- Help address anticipated rising sea levels and other reasonably foreseeable consequences of climate change and extreme weather events.
- Minimize the potential for public health and safety impacts from reduced quantity and quality of SWP water deliveries, and potentially CVP water deliveries, south of the Delta as a result of a major earthquake that could cause breaching of Delta levees and the inundation of brackish water into the areas where existing SWP and CVP pumping plants operate in the southern Delta.
- Protect the ability of the SWP, and potentially the CVP, to deliver water when hydrologic conditions result in the availability of sufficient amounts of water, consistent with the requirements of state and federal law, including the CESA, ESA, and Delta Reform Act, as well as the terms and conditions of water delivery contracts and other existing applicable agreements.
- Provide operational flexibility to improve aquatic conditions in the Delta and better manage risks of further regulatory constraints on project operations.

7.9.1.3. Guiding Principles

To ensure that future authorizations of Sites and DCP are consistent with Reclamation and DWR's policies, guidelines, and procedures for its authorization, funding, and operation of water projects, Reclamation and DWR propose to follow guiding principles to avoid, minimize, and offset adverse effects of the proposed operations to listed species and critical habitat. Guiding principles will inform the upfront development of operational criteria and measures to avoid or minimize effects to listed species and critical habitat, including possible adjustment through adaptive management.

As described further in Reclamation's BA (U.S. Bureau of Reclamation 2023-2024), guiding principles relevant to sDPS green sturgeon include:

- Upper Sacramento River
    - Utilize the additional water supply provided by Sites to address adverse effects of the CVP on sDPS green sturgeon habitat in the Sacramento River above the Red Bluff Pumping Plant by:
        - Implementing additional mitigation actions as necessary and appropriate to maintain and/or improve spawning and rearing habitat for anadromous fish in the Upper Sacramento River
        - Implement pulse flow criteria to provide migrating anadromous fish an opportunity to migrate past the diversion locations with minimum exposure to diversions

- Sacramento River from the Red Bluff Pumping Plant to Knights Landing
    - Implement actions necessary to minimize potential impacts to listed species exposed to diversion facilities
    - Implement pulse flow criteria to provide migrating anadromous fish an opportunity to migrate past the diversion locations with minimum exposure to diversions
    - Utilize the best available science to establish flow levels necessary to provide migratory and rearing habitat to minimize effects to juvenile anadromous fish survival and facilitate their movement out of the river toward the Delta and bays

- Below Knights Landing and, in the Delta,
    - Operate projects consistent with existing and/or future regulatory requirements in the Delta
    - Implement pulse flow criteria to provide migrating anadromous fish an opportunity to migrate past the diversion locations with minimum exposure to diversions and further minimize effects to through-Delta survival
    - Utilize the best available science to establish flow levels necessary to provide migratory and rearing habitat to minimize effects to juvenile anadromous fish survival and facilitate their movement out of the river toward the Delta and bays
    - Monitor and mitigate the effects of diversions on migrating anadromous species and their habitat through the identification of opportunities to develop additional

habitat (i.e., tidal and channel margin restoration) to maintain and/or improve the productivity of those fish populations
    - Protect habitat conditions supporting listed pelagic and anadromous species, and mitigate potential flow-related effects of Sites with habitat restoration developed in coordination with NMFS, USFWS, and CDFW to maintain and/or improve the productivity of those fish populations
    - Cooperate in the monitoring of the Fremont Weir Big Notch Project to assess what effect, if any, diversions of flow to Sites Reservoir have on the effectiveness of the Big Notch Project's ability to achieve its juvenile entrainment and adult passage performance goals for salmonids in the Sacramento River, and, if necessary, implement operational measures to avoid diminishing the performance of the Big Notch Project

As described in Reclamation's BA (U.S. Bureau of Reclamation 2023-2024), relevant guiding principles for the proposed operations of DCP include:

- Operate projects consistent with existing and/or future regulatory requirements in the Delta
- Implement pulse flow criteria to provide migrating anadromous fish an opportunity to migrate past the diversion locations with minimum exposure to diversions and further minimize effects to through-Delta survival
- Utilize the best available science to establish flow levels necessary to provide migratory and rearing habitat to minimize effects on juvenile anadromous fish survival and facilitate their movement out of the river toward the Delta and bays
- Monitor and mitigate the effects of diversions on migrating anadromous species and their habitat through the identification of opportunities to develop additional habitat (i.e., tidal and channel margin restoration) to improve the productivity of those fish populations
- Protect habitat conditions supporting listed pelagic and anadromous species, and mitigate potential flow-related effects of DCP with habitat restoration developed in coordination with NMFS, USFWS, and CDFW to improve the productivity of those fish populations
- Implement project operations and maintenance consistent with the proposed project description as an integrated component of the SWP
- Update and align elements of project description with conditions (e.g., regulatory, climate, and status of species) in the future consultation on DCP operations and maintenance in advance of operations of the North Delta diversions
- Use an AMP that would integrate with the AMP to test operational modifications to remedy or lessen unanticipated effects

7.9.1.4. Adaptive Management

Although there is no regulatory mechanism to modify an ESA authorization absent reinitiating the ESA section 7 consultation, there are options to improve understanding or modify an action through adaptive management so long as doing so does not meet a regulatory defined reinitiation trigger (50 CFR 402.16). Specifically, new information or a change in the proposed action would require reinitiation of consultation if: (a) new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not previously considered, or

(b) the identified action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in the biological opinion or written concurrence.

Both Sites and DCP would have AMPs that integrate with the LTO AMP. The Sites and DCP AMPs will include principles to cooperate and participate with ongoing monitoring programs; include design studies, in cooperation with resource agencies, to test modifications to operations that may be implemented to remedy or lessen unanticipated effects identified by the monitoring program; cooperate with the resource agencies to evaluate results of studies and determine whether changes in project operations are necessary and appropriate to address unanticipated adverse effects; integrate Sites and DCP adaptive management and monitoring with existing and proposed special studies, monitoring programs, technical teams, adaptive management, and structured decision-making processes associated with the LTO; and commit to collaborative decision-making processes consistent with the LTO adaptive management effort, including reliance on the Adaptive Management Steering Committee (AMSC), LTO adaptive management wheel, and structured decision-making framework.

7.9.1.5. Monitoring

Project-specific compliance efforts and monitoring would be the responsibility of the individual projects, but there would be a commitment to ongoing coordination and information sharing to support the broader monitoring and adaptive management processes. The AMP would document all activities associated with the planning phase of adaptive management and describe the process to be followed during the implementation, evaluation, and response phases. Project objectives were considered in identifying where adaptive management would be most effective and applicable for the project. If the proposed project is approved, as appropriate, mitigation measures identified, such as the implementation of the habitat creation and restoration actions, would integrate the concept of adaptive management in mitigation plan design, stand-alone site, and/or resources-specific adaptive management plans.

7.9.1.6. Framework Effects Analysis

Both DCP and Sites are designed to improve water management capabilities for SWP and CVP and collectively respond to challenges associated with future climate change. In particular, the projects are intended to provide for facility updates and improve the ability for SWP and CVP to respond to more extreme weather driven by climate change by improving the ability to capture, store, and convey water associated with flashier flow events, as well as a predicted general shift in hydrograph with relatively higher flows in winter months and reductions in the spring. As described qualitatively above, both DCP and Sites incorporate operational criteria intended to minimize potential effects to the environment and aquatic resources both at the facilities (near-field) as well as downstream (far-field). While these criteria have been designed to integrate with existing regulations and reduce the potential effects of each project individually, there are potential interactive effects that are important to further investigate and account for, mainly associated with changes to Sacramento River flows upstream of, in, and through the Delta. Potential effects to aquatic resources associated with these changes include:

- Changes to timing, magnitude, and duration of flows and possibly water temperatures along the Sacramento River/Delta corridor

- Subsequent changes to important aquatic constituents (e.g., suspended sediment, nutrients, and lower trophic production) associated with the flow modifications
- Potential changes to quantity/quality of habitat supporting listed species spawning, rearing, and migration
- Potential changes in the production of listed aquatic species

Given the framework-level programmatic nature of this action component, where further commitment and collaborative planning are necessary to identify effects and quantify a level of benefit and incidental take, it is still possible to estimate a general level of impact qualitatively.

7.9.1.7. Summary of Effects of Sites and DCP in Addition to the Proposed Action

Table 161, Table 162, Table 163, and Table 164 provide a qualitative summary of Sites- and DCP-related stressors to species and critical habitat that increase when added to the proposed action.

Exposure

Adult and juvenile SR winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon will be exposed to the operational effects of Sites and DCP. Species would generally be present during winter and spring months as they migrate upstream and downstream through the operational footprint, although there are some general exceptions that are described in greater detail in the Status of the Species section of this opinion. Affected attributes of designated critical habitat are freshwater rearing sites and migration corridors, riparian habitat, access for juvenile migration, and estuarine rearing and migration.

Juvenile and adult listed fish species will be exposed to operational effects primarily during the winter and spring months and, to a lesser extent, during the summer and fall. Sub-adult sDPS green sturgeon could be exposed during all months.

Exposure to operational effects using diversion criteria such as minimum bypass flows, pulse flow criteria and protections, and other guiding principles will be used to develop more details in refining a final proposed action.

In general, exposure to operational effects would be medium to high due to the large number of individuals of each species that migrate through the operational footprint.

Response

The large suite of potential effects of Sites and DCP to listed species is from operational effects. Sublethal and lethal effects on juvenile rearing and out-migration are associated with exposure to new or existing diversion facilities and fish screen structures and reduced out-migration flows for juveniles in the Sacramento River and the Delta. Other adverse effects to individuals include increased stranding risks of salmon and steelhead associated with an expected reduction in the number of days that the Fremont Weir will overtop and impacts to juvenile rearing and out-migration conditions associated with reduced flows and associated out-migration cues and conditions that reduce survival. Both projects will be operated with operational criteria, including factors such as pulse protection criteria and bypass flows, wherein diversions are restricted based on large-scale downstream movement of juvenile salmonids to minimize the potential for negative effects. Compensatory mitigation would be undertaken for hydrodynamic effects, including the potential for reduced riverine flow leading to the potential for lowering the river and possible impacts to critical habitat features. In general, the objectives, guiding principles, adaptive management, and monitoring are consistent with conservation objectives of the long-term operation of the CVP and SWP.

A large suite of potential effects to individuals and PBFs of designated critical habitat are proposed to be minimized or avoided through established guiding principles, best management practices, adaptive management strategies, and monitoring and compensatory mitigation

strategies. At this time, without specific operations plans and detailed modeling of integrated operations with the CVP and SWP, we determine that there would be a low to medium level of impact to individuals and critical habitat. However, it is not possible to discern the full scope of those impacts, which will be closely evaluated in subsequent phases of development, authorization, and ESA section 7 consultation.

Table 161. Qualitative summary of Sites-related stressors to species that increase when added to the proposed action.

Species	Life Stage	Stressor Exposure	Individual Response/Effect	Proportion of Population	Frequency	Potential Impacts to Individuals, Summary and Rationale
Sacramento River Winter-run Chinook salmon Central Valley Spring-run Chinook salmon California Central Valley Steelhead Southern distinct population segment of	Adult migration	Stranding Risk	Sublethal to Lethal	Salmon and Steelhead = Low Green sturgeon = medium to high	Semi-annual	Moderate Effects due to the reduced number of days that upstream passage conditions will be met at Fremont and Colusa Weirs.
	Holding and Spawning	Spawning Habitat Availability	Lethal	Low	Low	Low Weighted usable area quantitative analyses show limited effects of Sites operations, with minor increases to the stressor tending to occur in April–June and minor decreases to the stressor tending to occur in July.
	Juvenile Rearing and Out-migration	Toxicity from Contaminants	Sublethal	Low	Medium	Low Sites reservoir releases have minor potential for negative effects from metals and pesticides, although juvenile rearing and out-migration generally would be outside the main period of reservoir releases.

Species	Life Stage	Stressor Exposure	Individual Response/Effect	Proportion of Population	Frequency	Potential Impacts to Individuals, Summary and Rationale
Green Sturgeon		Predation and Competition	Sublethal to Lethal	Medium	Low	Low to Medium Available studies suggest there would be limited effects of Sites diversions on predation risk at the Red Bluff and Hamilton City intakes; uncertainty would be addressed with technical studies of predator density and distribution.
		Reduced Flows and Out-Migration Cues	Lethal	Low to Medium	Medium	Medium Sites diversions would reduce out-migration flows for juveniles in the Sacramento River and the Delta, which is to be minimized with diversion criteria (Bend Bridge Pulse Protection and Minimum Bypass Flows in the Sacramento River at Wilkins Slough)

Table 162. Qualitative summary of Sites-related stressors to critical habitat that increase when added to the proposed action.

Critical Habitat Feature	Species	Stressor Exposure	Effect	Potential Impacts To Elements of Critical Habitat
Emergence, and Downstream Transport of Juveniles Freshwater Rearing Sites Freshwater Migration Corridors Habitat and Adequate Prey that are not Contaminated Riparian Habitat for Juvenile Development and Survival	Sacramento River Winter-run Chinook salmon Central Valley Spring-run Chinook salmon California Central Valley Steelhead	Juvenile Refuge Habitat	Adverse - Physical loss and impairment of habitat	Low - localized, small scale effects. Minimized through compensatory mitigation.
		Food Availability and Quality	Adverse - Reduction in food availability	Low - localized, small scale effects. Minimized through compensatory mitigation.
		Toxicity from Contaminants	Adverse	Medium - Sites reservoir releases have minor potential for negative effects from metals and pesticides.
		Refuge Habitat	Adverse	Medium - Sites diversions would reduce flow-inundated habitat in the Sacramento River.
Estuarine Areas Access Downstream for Juvenile Migration to San	Sacramento River Winter-run Chinook salmon Central Valley Spring-run	Entrainment Risk	Adverse	Low - There is the potential for other near-field negative effects such as impingement, which would be minimized by the fish screens meeting agency criteria.

Critical Habitat Feature	Species	Stressor Exposure	Effect	Potential Impacts To Elements of Critical Habitat
Francisco Bay and the Pacific Ocean	Chinook salmon California Central Valley Steelhead	Out-migration cues	Adverse	Medium - Sites diversions would reduce out-migration flows for juveniles in the Sacramento River and the Delta, to be minimized with diversion criteria (Bend Bridge Pulse Protection and Minimum Bypass Flows in the Sacramento River at Wilkins Slough).
Estuarine Habitats	Southern distinct population segment of Green Sturgeon	Water Flow	Adverse	Medium - Reduced Delta Outflow

Table 163. Qualitative summary of Delta Conveyance Project (DCP)-related stressors to species that increase when added to the proposed action.

Species	Life Stage	Stressor Exposure	Individual Response/Effect	Proportion of Population	Frequency	Potential Impacts to Individuals, Summary and Rationale
Sacramento River Winter-run Chinook salmon Central Valley Spring-run Chinook salmon California Central	Adult migration	Toxicity and Contaminants	Sublethal	Low	Low	Low DCP construction effects from sediment disturbance and construction contaminants.
		Noise and Disturbance	Sublethal	Low	Low	Low DCP construction effects would be limited in temporal overlap because of a work window.
	Juvenile Rearing and Out-migration	Toxicity from Contaminants	Sublethal	Low	Low	Low DCP construction effects from sediment disturbance and construction contaminants minimized by best management practices.

Species	Life Stage	Stressor Exposure	Individual Response/Effect	Proportion of Population	Frequency	Potential Impacts to Individuals, Summary and Rationale
Valley Steelhead Southern distinct population segment of Green Sturgeon		Predation and Competition	Sublethal to Lethal	Low	Low for Construction High for Operations	Low to Medium DCP construction has the potential to disturb juveniles and make them more susceptible to predation. Minimized by work window best management practices. Predation associated with DCP operations could occur at the North Delta intakes if predators aggregate there, but existing literature suggests such effects would be minimal; uncertainty to be addressed with fisheries studies and adaptive management.
		Pathogens and Disease	Sublethal	Small	High	Low Small potential for injury leading to disease from contacting North Delta intake screens, minimized by screen design (smooth screen face; cleaning system) and operating criteria (e.g., approach velocity).
		Stranding Risk	Lethal	Low	Low	Low DCP construction has the potential to strand juveniles within cofferdams, but there would be limited temporal overlap with the construction window.

Species	Life Stage	Stressor Exposure	Individual Response/Effect	Proportion of Population	Frequency	Potential Impacts to Individuals, Summary and Rationale
		Reduced Flows and Out-migration Cues	Lethal	High	High	Medium DCP North Delta intake operations would reduce Sacramento River flow into the Delta, potentially reducing through-Delta survival based on flow-survival relationships. This will be limited by operating criteria.
		Entrainment Risk	Lethal	High	High	Low Reduced through screen criteria
		Refuge Habitat	Sublethal	Low	Low for Construction High for Operations	Low to Medium Minimized by construction windows and compensatory mitigation of lost habitat.
		Food Availability	Sublethal	Low	Low	Low DCP construction may affect food availability through disturbance or reduced habitat, which would be small in extent, limited in temporal overlap because of work windows, and minimized or compensated for by conservation measures.

Species	Life Stage	Stressor Exposure	Individual Response/Effect	Proportion of Population	Frequency	Potential Impacts to Individuals, Summary and Rationale
		Noise and Disturbance	Sublethal to Lethal	Low	Low	Low Minimized due to work windows.

Table 164. Qualitative summary of Delta Conveyance Project (DCP)-related stressors to critical habitat that increase when added to the proposed action.

Critical Habitat Feature	Species	Stressor Exposure	Effect	Potential Impacts To Elements of Critical Habitat
Emergence, and Downstream Transport of Juveniles Freshwater Rearing Sites Freshwater Migration Corridors Habitat and Adequate Prey that are not Contaminated Riparian Habitat for Juvenile Development and Survival	Sacramento River Winter-run Chinook salmon Central Valley Spring-run Chinook salmon California Central Valley Steelhead	Juvenile Refuge Habitat	Adverse - Physical loss and impairment of habitat	Low - localized, small-scale effects. Minimized through compensatory mitigation.
		Food Availability and Quality	Adverse - Reduction in food availability	Low - short-term construction-related impacts
		Stranding risk	Adverse - short term impacts to habitat due to installation of cofferdams	Low - short-term construction-related impacts
Estuarine Habitats	Southern distinct population segment	Food Resources	Adverse - through disturbance, water quality effects, or reduced habitat.	Low - short-term construction-related impacts

Critical Habitat Feature	Species	Stressor Exposure	Effect	Potential Impacts To Elements of Critical Habitat
	of Green Sturgeon	Water Flow	Adverse	Medium - Reduced Delta Outflow
		Water Quality	Adverse - through disturbance, water quality effects	Low - short-term construction-related impacts
		Migratory Corridor	Adverse - through disturbance, water quality effects	Low - short-term construction-related impacts
		Sediment Quality	Adverse - through disturbance, water quality effects	Low - short-term construction-related impacts

7.9.2. Spring Delta Outflow

Reclamation and DWR will take actions to supplement Delta outflow per the terms of the VAs. Reclamation and DWR's Spring Outflow Action is characterized as Pre-and Post-adoption action elements. Pre-adoption action elements are integrated into water operations and analyzed as part of the site-specific consultation in the Effects of the Action, Bay-Delta Division section of this opinion. Post-Adoption Implementation is dependent on a future action by the SWRCB and other VA parties and is the subject of this framework programmatic analysis.

7.9.2.1. Pre-Adoption

During the pre-adoption period, Reclamation and DWR will make water available for Spring Delta Outflow through foregone exports as described in Table 165, and DWR may operate to Section 3.3.3.2 Early Voluntary Agreement Implementation of their November 2024 ITP for the LTO of the SWP (California Department of Fish and Wildlife 2024c) instead of their share of the volumes described in Table 165. These are analyzed in the effects analysis for the Bay-Delta Division as project-specific actions.

7.9.2.2. Post-Adoption

Reclamation and DWR will operate consistent with the VAs only if (a) the SWRCB incorporates the VAs, as proposed by the VA parties, into the Water Quality Control Plan, and (b) the VA parties execute the agreements contemplated in the VAs.

If the SWRCB incorporates VAs into the Water Quality Control Plan and the VA parties execute the agreements contemplated by the VAs, Reclamation will request site-specific stepped-down, or tiered consultations, with details about how coordinated operations will be implemented to comply with the Water Quality Control Plan with VAs. For framework programmatic actions, an incidental take statement is not required at the programmatic (framework) level for those actions falling within the definition of a framework programmatic action (50 CFR 402.02). The site-specific or tiered consultations will include an incidental take statement if incidental take is likely to occur as a result of Post-Adoption Actions.

Table 165. Actions to result in increased Delta outflow. These volumes (and associated footnotes) are reflected in the Memorandum of Understanding signed by Voluntary Agreement (VA) parties in March 2022.

	Critical (TAF)	Dry (TAF)	Below Normal (TAF)	Above Normal (TAF)	Wet (TAF)
SWP and CVP Forgone Exports[1]	0	125	125	175	0
SWP Flow Purchases Implemented through Forgone SWP exports	0	30	30	30	0

	Critical (TAF)	Dry (TAF)	Below Normal (TAF)	Above Normal (TAF)	Wet (TAF)
Sacramento River Settlement Contractors Fallowing[2]	2	102	100	100	0
Sac. Valley Purchase[3]	0	10	10	10	0
American River Groundwater and Reoperation of Upstream Reservoirs[4]	30	40	10	10	0
CVP SOD Purchase10[5]	0	12.5	24.5	35	0
Westlands Contract Assignment Purchase[6]	3	6	15	19.5	27
Additional CVP SOD[7]	0	5	5	5	0
San Joaquin River Flows above Tributary VAs	0	50	50	50	0
Flow Purchases Acquired Through SWP Diversion Fees (implemented through tributary inflow from the fallowing program)[8]	0	45	45	45	0
Total CVP and SWP Outflow Potentially through CVP and SWP Operations[9]	33	423.5	414.5	478.5	27
Additional Feather River Actions accounted for under Total VA Outflow (below)		60	60	60	
Total VA Outflow by All VA Parties	155	825.5	750.5	824.5	150

CVP = Central Valley Project; SWP = State Water Project; TAF = Thousand Acre-Feet; SOD = South of Delta.

[1] Subject to Public Health and Safety exports of 1,500 cfs.

[2] Sacramento River Settlement Contractors will fallow 25,000 acres of rice, which is credited with 110 TAF, which includes 10 TAF of fixed-price purchase water. Dry year water may be held in Shasta for storage to improve temperature management in the current or future years. Two TAF in critical and dry years are contributions from Mill/Cow Creek.

[3] The new flow contributions from the Sacramento River basin identified in this table, plus new flow contributions resulting from the below-referenced Public Water Agencies (PWA) Water Purchase Program, Permanent State

Water Purchases, and PWA Fixed Price Water Purchase Program line items in Tables 1a and 1b, are not intended to result in idling more than 35,000 acres of rice land in the Sacramento River basin.

[4] Contingent on public funding of groundwater substitution infrastructure to be completed by a subsequent year, and compensation of upstream surface storage releases on a per acre-foot basis. These flows are included in the Year 1 subtotal. Only implementable in 3 of 8 dry or critical years and 3 of 8 above normal or below normal years.

[5] Subject to CVP SOD Agricultural Allocation.

[6] Quantity of water made available will be based on the maximum or a portion of the entitlement under certain assignment contracts and only that which is allocated to CVP SOD Agriculture.

[7] If flows are not obtained through this source, the equivalent volume would be obtained at market price or otherwise obtained through other mechanisms.

[8] The VA's governance program will be used to determine the use of available funding to provide additional outflow in above normal, below normal, or wet years. If DWR is called upon to provide the water by foregoing SWP exports, such a call will be handled through a separate agreement between DWR and its contractors. The numbers for "Flow Purchases Acquired Through SWP Diversion Fees (implemented through tributary inflow from the fallowing program)" are the SWP's partial contributions to the total values set forth in the Term Sheet, Appendix 1 under the PWA Water Purchase Program's fallowing contributions for above normal, below normal, and dry years.

[9] The volumes identified in this row represent the CVP and SWP contributions. Additional flows from other VA parties and Permanent State Water Purchases will increase Delta Outflow.

Given the framework-level programmatic nature of this action component, where further commitment and collaborative planning are necessary to identify effects and quantify a level of benefit and incidental take, it is still possible to estimate a general level of impact qualitatively. NMFS applies the following assumptions regarding the potential species exposure and response.

7.9.2.3. Exposure

Exposure to the VAs is based on the timing and duration of the action and the seasonal presence of ESA-listed fish species. If Reclamation and DWR were to implement actions consistent with the terms of the VAs, we expect that actions would be carried out consistent with export curtailments, water purchases, reservoir re-operations, and other actions that would contribute to the total outflow volumes described in Table 165. The frequency with which species would be exposed to the total outflow volumes is not specifically certain at this time because the VAs have not been approved by the SWRCB and the executing agreements are yet to be signed. The duration of exposure would be yearly for a period of up to 8 years. Exposure would also depend on water year type. Generally, the water volumes proposed to be deployed by the VA parties are lowest in critical and wet water years and higher in dry, below normal, and above normal water year types.

More specifically, we expect the following details and assumptions are important for considering exposure throughout the system:

Sacramento River

- The following species could be affected by the VAs in the Sacramento River: SR winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead and sDPS green sturgeon. Exposure to the spring outflow action component would occur in spring months and directly expose juvenile and adult CV spring-run Chinook salmon, juvenile CCV

steelhead, and possibly sDPS green sturgeon. Deferring SRSCs' volumes to other months to help support Shasta storage would expose SR winter-run Chinook salmon.

- Water for pulse flows is generated through 25,000 acres of land fallowing in the Sacramento Basin.
- Pulse flows are protected through the Delta.
- Pulse amounts are determined using 50 percent exceedance of the forecasted Sacramento Valley (40-30-30) Index Water Year type in April.
    - In above normal/below normal water years, 95 TAF pulse releases are split between April and May.
    - In dry water years, water saved from land fallowing is stored in an account in Shasta Reservoir, then released as a pulse in the following year split between April–May. Account storage is water savings that can be backed up into Shasta Reservoir, reduced by the volume that spills. Spills of this VA water occur only after all proposed action account water has spilled. If the following year is an above normal/below normal year, then the pulse is 95 TAF plus any dry year carryover.
- Water savings from land fallowing occurs throughout the irrigation season. Water is either released for the VA pulse directly (April–May in above normal/below normal years) or backed up into Shasta Reservoir. In months where water cannot be backed up, water is exported at Jones Pumping Plant if possible, or routed out the Delta.

Feather River

- The following species could be affected by the VAs in the Feather River: CV spring-run Chinook salmon, CCV steelhead, and possibly sDPS green sturgeon.
- Water for pulse flows is generated through 10,000 acres of land fallowing in the Feather River basin.
- Pulse flows are protected through the Delta.
- Pulse amounts are determined using 50 percent exceedance of forecasted Sacramento Valley (40-30-30) Index Water Year type in April.
- Pulse releases of 60 TAF in above normal/below normal/dry years.
- Pulse releases split between April and May, but flow releases can continue later in the year depending on the timing of spills.

American River

- CCV steelhead could be affected by the VAs in the American River.
- Pulse flows provided in March–May in all but the wet water year type based on the Sacramento Valley (40-30-30) Index.
- Pulse flows are protected through the Delta.
- Pulse volumes are supported by upstream storage volumes.

San Joaquin River

- The following species could be affected by the VAs in the San Joaquin River: CV spring-run Chinook salmon and CCV steelhead.
- 50 TAF flow contribution in the SJRRP in dry, normal-dry, and normal-wet years during February–May.

- Flows are protected through the Delta.
- Friant Dam flood releases and restoration flows can contribute to meeting the VAs.
- If necessary, recapture is reduced so that restoration flows can go to outflow. Delta recapture is foregone first, and Lower San Joaquin River recapture second (only if needed).
- Restoration flows can be recaptured whether or not Friant Dam is spilling, and hence foregone under the same conditions. Recapture can be foregone up to a maximum of 50 percent during the period of February through May. If 50 percent is not sufficient to meet the 50 TAF flow goal, then no more contribution is required.

Bay-Delta

- The following species could be affected by the VAs in the Bay-Delta: SR winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon.
- Reclamation and DWR will provide the foregone exports described in Table 165.
- Sacramento, Feather, American, and San Joaquin river flows are protected through the Bay-Delta.

7.9.2.4. Response

Species' responses to Post-Adoption operations in the Delta are captured in the modeling completed by Reclamation for the LTO consultation. Stressors influenced by the VAs in the Delta include:

- **Flow Conditions**, which affect routing in the Delta and through-Delta survival
- **Entrainment,** the direct estimate of which is considered in salvage and loss calculations

Stressors affected by the proposed action in Delta tributaries include:

- **Holding and Spawning**, as survival for SR winter-run Chinook salmon in the Sacramento River
- **Rearing and Migration**, in terms of survival for out-migrating CV spring-run Chinook salmon, CCV steelhead, and possibly sDPS green sturgeon in occupied waters

If Reclamation and DWR were to implement the VAs, there would be a long-term (up to 8 years) response to the action associated with improved flow conditions and reduced entrainment in the Delta during April and May and improved survival over baseline for rearing and migration. These responses are consistent with the objectives of the long-term operations of the CVP and SWP to implement actions that reduce entrainment and improve survival through the Delta. These responses would mostly affect juvenile fish in particular, as they are most susceptible to entrainment and flow-related survival. There may also be some responses to juvenile rearing and survival during spring months on the Sacramento and American rivers during certain water year types. Spring reservoir releases could result in some adverse effects associated with re-operation of certain reservoirs, particularly Shasta and Folsom reservoirs on the Sacramento and American rivers, respectively. These adverse effects would be in the form of summer temperature impacts that reduce SR winter-run Chinook salmon egg incubation and survival on the Sacramento River

and summer and fall temperature impacts that influence CCV steelhead survival on the American River.

If Reclamation and DWR were to implement the VAs, the risk of potential impacts to individuals would generally be low for a number of reasons. First, reduced exports are expected to reduce the risk of entrainment into the interior Delta and at the export facilities. Also, although the contributions from tributaries are relatively low, higher instream flows during spring months are generally associated with higher juvenile survival. There are potential adverse impacts associated with the re-operations of reservoirs because blocks of water that may have otherwise been stored for managing summer water temperatures may be repurposed for releases that support Delta outflow and spring-pulse flows. The potential impacts are probably most notable on the Sacramento and American rivers. The Shasta Framework includes a decision-making process where the SHOT will consider these effects and deploy VA assets in a manner that may benefit the most at-risk life stages or provide the greatest benefit to survival. On the American River, there is no such framework or governance process for where these tradeoffs can be considered; however, the American River contributions will only occur in 3 out of 8 years, so potential impacts are considered low-risk and may be balanced with the beneficial outcomes of higher spring flows in the American River and through the Delta.

7.9.3. Drought Response: Drought Toolkit

The Drought Response in the proposed action (Section 3.12: Drought, in U.S. Bureau of Reclamation 2023-2024), and the associated Drought Toolkit (Appendix XX in U.S. Bureau of Reclamation 2023-2024), is considered a programmatic element of the proposed action because, at the time of this consultation, it cannot be defined what actions and where those actions may be needed to address drought conditions, nor may it be determined how frequently those actions will be necessary. This is largely due to the unpredictable nature of droughts, the inherent challenges of predicting where, when, and how drought impacts may impact protected fish species and their habitats, and the need to tailor specific drought response actions. Despite the inability to forecast prolonged (interannual) drought and the response necessary to mitigate drought effects, the proposed action approach to drought response is more developed for the Shasta Division of the CVP described in Section 3.2, Framework Approach, of Reclamation's BA (U.S. Bureau of Reclamation 2023-2024) than it is in other divisions. Specific to the Shasta Management Plan, the SHOT may identify actions from the Drought Toolkit as needed to address drought conditions in Bin 2B, 3A or 3B years. Implementation of those actions would be coordinated with WOMT regarding the potential downstream impacts.

Likewise, to manage drought impacts across the entirety of the CVP and SWP system, the Drought Toolkit (Appendix XX in U.S. Bureau of Reclamation 2023-2024) provides a description of the general Governance of the Drought Relief Year (DRY) Team. The DRY Team will convene on an annual basis to assess the need for drought response actions in water years where hydrology or water storage (e.g., drought) present challenging water management decisions that cannot be fully addressed by annual operations planning. In those years, the DRY Team will coordinate and review potential Drought Toolkit actions meant to avoid or mitigate drought impacts.

7.9.3.1. Qualitative Assessment of the Drought Toolkit

As a primary tool of the DRY Team, and as a resource for managers (e.g., SHOT and WOMT), the Drought Toolkit is an approach by which the DRY Team may coordinate with the SHOT and WOMT to recommend and evaluate the implementation of drought actions. Each action within the toolkit is summarized and scheduled according to the management relevant milestones needed to achieve its implementation. Additionally, previous implementation and evaluation records are provided as a means to improve the understanding of what actions were successful and why.

Within the Drought Toolkit, each action is categorized as an avoidance action or mitigation action. An avoidance action is one that can be taken to bring about more permanent changes that limit drought impacts when droughts occur, whereas a mitigation action can be taken immediately during a drought to directly limit the impacts in that specific drought. This characterization allows the DRY Team and managers to consider both long-term actions to avoid drought conditions (e.g., infrastructure improvements) and provide the flexibility to identify rapid response actions to mitigate drought within the context of seasonal changes in operations or the biology of endangered and threatened species. Actions in the toolkit are meant to act as starting points and guides. Managing natural resources during drought conditions will require collaboration and communication between the DRY Team, state and federal agencies, technical experts, public water agencies, and other interested parties to ensure all actions taken meet regulatory standards. Given the framework-level programmatic nature of this action component, where a commitment has been made to further evaluation and authorization, or where collaborative planning may be necessary but where further authorization is not, it is possible to estimate a general level of impact qualitatively.

NMFS provides a qualitative assessment of the exposure and response of the drought response actions so as to provide a basis of understanding of the potential effects of each action. Although assessed qualitatively, NMFS still applies the same approach to evaluating the effects of the Drought Toolkit, applying the following assumptions regarding the potential species exposure, and response:

- **Exposure:** Species exposure is dependent on the species affected and the life stage timing coinciding with a particular drought condition at a particular location. Some drought response actions are identified as avoidance actions where they provide a mechanism to avoid or reduce the exposure of a species to a stressor.
- **Response:** Generally, the species response would be expected to be beneficial by avoiding a stressor effect or reducing the severity of the stressor. The potential effects associated with any of the Drought Toolkit actions are relative to the frequency that they would be applied, which is, in turn, a reflection of the frequency that drought conditions would manifest.

At the time of this consultation, there are 25 drought response actions that are included in the Drought Toolkit, however, more may be added as new approaches and actions are developed to address future drought conditions. Prior to the implementation of some of these actions, there will be further analysis or consultation to quantify a level of effect and provide ESA take authorization if necessary (Table 166).

Table 166. Drought Toolkit actions and status regarding existing authorization.

Drought Toolkit Action	Future project-specific consultation or authorization	Existing authorization or no authorization necessary
Action 1: Water Transfers by Sacramento River Settlement Contractors (SRSC)		X
Action 2: Increasing Seasonal Food Availability for Juvenile Chinook Salmon	X	
Action 3: SRSC Diversion and Operation Communication		X
Action 4: Request Modified Fall Diversion Schedule by SRSC		X
Action 5: Request Modified Spring Diversion Schedule by SRSC		X
Action 6: Release Water through River Outlets		X
Action 7: Salmon eDNA Early Warning		X
Action 8: Nimbus Hatchery Drought Preparations	X	
Action 9: Temporary Urgency Change Petition		X
Action 10: Emergency Drought Salinity Barrier	X	
Action 11: Curtailments		X
Action 12: Emergency Clear Creek Pulse Flow		X
Action 13: Infrastructure Improvements at Livingston Stone National Fish Hatchery	X	
Action 14: Lower Pump Intakes Near Wilkins Slough	X	

Drought Toolkit Action	Future project-specific consultation or authorization	Existing authorization or no authorization necessary
Action 15: Installation of the Shasta Temperature Control Device Middle Gate Curtain		X
Action 16: Aquatic Vegetation Monitoring		X
Action 17: Delta Ecosystem Monitoring and Synthesis		X
Action 18: Increased Production at Livingston Stone National Fish Hatchery	X	X
Action 19: Drought Feather River Spring Flow Redistribution	X	
Action 20: Folsom Dam Power Bypass		X
Action 21: Harmful Algal Bloom Monitoring		X
Action 22: Translocation of Naturally Spawning Sacramento River Chinook Salmon	X	
Action 23: Relocation of Central Valley Spring-Run Chinook Salmon Collected Incidentally at the Keswick Dam Fish Trap to Clear Creek	X	
Action 24: Relocation of Adult Sacramento River Winter-Run Chinook Salmon Trapped at Coleman National Fish Hatchery and the Keswick Dam Fish Trap to Battle Creek, Upstream of Eagle Canyon Dam	X	
Action 25: Incubate a Portion of Sacramento River Winter-Run Chinook Salmon Eggs from Livingston Stone National Fish Hatchery Along the McCloud River	X	

Action 1: Water Transfers by Sacramento River Settlement Contractors

Through the voluntary water transfers by the SRSCs, the SRSCs would pump groundwater in lieu of diverting surface water otherwise provided by Reclamation operations. Reclamation

would then make the surface water available for transfer later in the year. The SRSCs may also idle lands that would have been planted absent the transfer, or plant a crop with a lesser water demand than what otherwise could have been planted to make surface water available for transfer later in the year.

The effect of this drought action would be to increase stored water in upstream reservoirs (i.e., Shasta Reservoir) that would have been made available in the months of April, May, and June consistent with the contracted schedule. That stored water would contribute to the availability of a cold-water pool which would be used to maintain suitable egg incubation temperatures in the summer months when released and made available for transfer from the SRSCs in July, August, and September. In this way, transfers may increase storage in upstream reservoirs in April, May, and June, as compared to conditions without the transfer. In these months, river flows upstream of the point of diversion would be lower than those described by the typical (i.e., non-drought) operations. However, river flows downstream of the point of diversion would not be affected by the delayed diversions because without the transfers those waters would have been diverted.

Exposure: This Drought Toolkit action would expose a large proportion of migrating and holding adult SR winter-run Chinook salmon, CV spring-run Chinook salmon and CCV steelhead, and juvenile CCV steelhead originating from the Upper Sacramento River watershed to reduced river flows in the months of April, May, and June. This action would also expose a large proportion of spawning adults and incubating eggs of SR winter-run Chinook salmon and CV spring-run Chinook salmon and juvenile CCV steelhead originating from the Upper Sacramento River watershed to reduced river temperatures in the months of July, August, and September.

Response: The flow reductions in the months of April, May, and June are likely to be relatively small in volume and would be limited to the mainstem Sacramento River above the point of diversion. Individual response is expected to result in a minor or sub-lethal effect of reduced spawning success. The potential temperature benefits experienced in the months of July, August, and September are expected to be high, leading to increased spawning success and survival. The potential effects associated with this action are considered low as its implementation may be considered necessary in about 20 percent of years identified as “Bin 2B” or “Bin 3.”

This action, the water transfers by the SRSCs, would be considered during Reclamation’s annual forecast and water contract allocation processes, as well as the interagency development of the Shasta TMP. Given the further review and coordination of this action that is considered part of the governance of annual planning and real-time operations informed by the SRG and SHOT, as discussed in the Sacramento River Division effects analysis section of this opinion, NMFS has determined that no further project-specific ESA section 7 consultation would be necessary.

Action 2: Increasing Seasonal Food Availability for Juvenile Chinook Salmon

The action “increasing seasonal food availability for juvenile Chinook salmon” would apply the practices of the 2019 Food for Fish research project on rice fields in fall and winter months. During these months, the action would be expected to affect SR winter-run Chinook salmon. However, a key component of the action is to also study its effectiveness through technical evaluations focusing on (1) pump capacity at participating rice fields, (2) hydrodynamic and transport analysis to optimize release of rice field effluent based on drought year conditions and

presence of juveniles, and (3) bioenergetic analysis to estimate salmonid growth potential based on prey availability, water temperature, and initial fish size, the assessment of which would require the handling and take of fish. The potential benefits of this action include increasing in-river prey availability where salmon species may respond with increased growth rates.

To implement this action, the SRSCs would apply the Food for Fish practices on flooded fields after the growing season between December and March where rice decomposition from wetted rice fields produces abundant prey (e.g., zooplankton) for juvenile foraging and rearing Chinook salmon. The prey-dense rice-field water would be pumped back into the mainstem Sacramento River to increase prey availability for juvenile salmon rearing in the mainstem river and increase the growth rate of the fish therein. Larger fish are predicted to have greater subsequent survival rates, assuming larger fish have a higher average survival probability than smaller fish in the same life stage.

Exposure: A large proportion of migrating and rearing juvenile SR winter-run Chinook salmon would be exposed to this action from December through March. The monitoring element of this action is expected to expose a small proportion of fish needed to evaluate the effectiveness of the action.

Response: The response to the beneficial effects of the action would be small, resulting in an increased growth potential. This action also involves an additional diversion and return of water to the mainstem Sacramento River that could negatively affect those individuals exposed to predators, fish screen interactions, or entrainment into a diversion resulting in a decrease in survival and lifetime spawning success. Effectiveness monitoring of this action would require the capture, handling, and return of fish to the river, which would result in increased stress and potentially decreased growth. The potential for adverse effects associated with this action is considered low (infrequent; likely only occurring in about 20 percent of years identified as "Bin 2B" or "Bin 3").

This action involves the additional diversion and return of river waters, which may negatively affect fish. This action also includes a monitoring element that would involve the direct handling of listed species, incurring direct take of NMFS trust resources. Because of these operational and monitoring elements, this action will require additional consultation and authorization prior to implementation.

Action 3: Sacramento River Settlement Contractors Diversion and Operation Communication

Through this voluntary action, the SRSCs compile and provide diversion estimates to Reclamation and participate in calls or meetings to discuss SRSC diversions, operations, and river conditions. The increased sharing of information regarding SRSC diversions and operations during drought years allows Reclamation to better anticipate depletions in the Sacramento River and inform the release schedule from Keswick Reservoir. Particularly during the spring and fall months, the refined communication of daily SRSC diversion data can be helpful for Reclamation's planning purposes as it schedules releases from Shasta and Keswick Reservoirs. Regular updates and discussions with Reclamation allow the SRSCs to keep landowners and operators informed of challenges and upcoming changes in river conditions and operations.

Exposure: This action has the potential to expose a large proportion of migrating, holding, and rearing SR winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon in the Sacramento River watershed during the months of water contract diversion (i.e., March–October).

Response: The effects of this action are difficult to predict given the uncertainty as to how the increased communication would affect conditions in the Sacramento River. However, the magnitude of these effects is expected to be small, providing some improvement in managing storage and flows at the margin of proposed action operations. Species response is also likely to be relatively small or marginal, resulting in increased survival, spawning success and/or growth. As a drought toolkit action, the potential for adverse effects associated with this action is low, likely only necessary in a small number of years. However, the increased communication and coordination of reservoir releases and deliveries could improve operational efficiency in a large number of years.

This action, the SRSCs diversion and operation communication, would be considered during Reclamation's annual forecast and water contract allocation processes, as well as the interagency development of the temperature management plan. Given the further review and coordination of this action that is considered part of the governance processes of annual SRG and SHOT planning and real-time operations discussed in the Sacramento River Division effects analysis section of this opinion, no further project-specific ESA section 7 consultation would be necessary.

Action 4: Request Modified Fall Diversion Schedule by Sacramento River Settlement Contractors

Reclamation may request that the SRSCs voluntarily modify diversion schedules to reschedule fall (October) diversions to later weeks in October and into November. By rescheduling diversions to better align with the timing of Reclamation's release reductions from Keswick Reservoir, Reclamation may better meet the needs of multiple beneficial uses, including fishery needs and storage conservation.

Exposure: This action would expose a small to medium proportion of SR winter-run and CV spring-run Chinook salmon incubating eggs, as well as a medium proportion of spawning adult CV spring-run Chinook salmon and CCV steelhead, in the Upper Sacramento River watershed to stabilized river flows in October and November.

Response: As this action could be utilized to stabilize flows in the Upper Sacramento River, thereby reducing the potential for stranding of fry or dewatering of redds, the species response would be a small increase in spawning success and/or survival. As a drought toolkit action, the potential for adverse effects associated with this action is low, likely only practicable in a small number of years. However, the increased coordination of fall reservoir releases could improve operational efficiency in many years.

This action, the request to modify the fall diversion schedule by SRSCs, would be considered as part of the fall and winter baseflows for Shasta Reservoir refill and redd maintenance and rice decomposition smoothing operations. Given the further review and coordination of this action that is considered part of the governance processes of annual SRG and SHOT planning and real-

time operations, as discussed in the Sacramento River Division effects analysis section of this opinion, no further project-specific ESA section 7 consultation would be necessary.

Action 5: Request Modified Spring Diversion Schedule by Sacramento River Settlement Contractors

By this action, Reclamation may request that the SRSCs voluntarily consider scheduling early spring (April–May) diversions to later weeks in April and May. By rescheduling diversions to better align with the timing of Reclamation's release reductions and storage objectives, Reclamation may be better able to meet the needs of multiple beneficial uses, including fishery needs and storage conservation.

Exposure: This Drought Toolkit action would expose a medium proportion of migrating and holding adult SR winter-run Chinook salmon, CV spring-run Chinook salmon and CCV steelhead, and juvenile CCV steelhead originating from the Upper Sacramento River watershed to modified river flows in April and May.

Response: The effects of this action are difficult to predict, given the uncertainty as to how the spring flows would be redistributed. Average monthly flows may even remain the same as the shift in releases and operations may occur in the same month. Species response is likely to be small, but if the shift in operations were able to achieve a storage threshold necessary to accommodate a spring pulse flow, the benefit could increase, which would manifest as improved spawning success. As a drought toolkit action, the potential for adverse effects associated with this action is low, likely only practicable in a small number of years. However, the increased coordination of spring operations could improve operational efficiency in a medium number of years.

This action, the request to modify the spring diversion schedule by SRSCs, would be considered when establishing the adult migration and holding temperature objectives. Given the further review and coordination of this action that is considered part of the governance processes of annual SRG and SHOT planning as discussed in the Sacramento River Division effects analysis section of this opinion, no further project-specific ESA section 7 consultation would be necessary.

Action 6: Release Water Through River Outlets

Use of river outlets at various times for the release of water from Shasta Reservoir would provide flexibility in meeting temperature targets and preserve a cold water pool. The river outlets were used in April and May 2015 to release water from the upper elevations of the water column when water surface elevations were below the upper gates of the temperature control device.

Exposure: This Drought Toolkit action would expose a medium proportion of migrating and holding adult SR winter-run Chinook salmon, CV spring-run Chinook salmon and CCV steelhead, and juvenile CCV steelhead originating from the Upper Sacramento River watershed to increased river temperatures in the months of April and May. The objective of this action, however, is to conserve cold water pool volume for release later in the year (July, August, and September) to prolong temperature control.

Response: The temperature increases in the months of April and May are likely to be relatively small and would be limited to the mainstem Sacramento River in the reach just below Keswick Dam. Individual response is expected to result in a small proportional shift later in spawn timing (Dusek Jennings 2020), a potential increase in temperature-related pre-spawn mortality, and a reduction in gamete viability, reducing spawning success. The potential temperature benefit attributed to the conserved cold-water pool volume would be experienced in the months of July, August, and September, and are expected to be high, leading to increased spawning success and survival. The potential for adverse effects associated with this action is considered low as its implementation may be considered in about 20 percent of years identified as "Bin 2B" or "Bin 3."

This action, the release of water through river outlets, would provide greater flexibility in meeting tail bay temperature targets and preserving a cold water pool, which would in turn provide for temperatures that are supportive of species. Although it is very unlikely that this action would negatively affect the species, using the river outlets would bypass the penstocks, removing the ability to generate power from reservoir releases. Given that the potential risk of negative effects to species and habitat is low and that the decision whether to implement this action would only be made after consultation with the Western Area Power Authority and after the deliberation of SRG and SHOT to maximize the potential species benefit and reduce potential loss in power generation as discussed in the Sacramento River Division effects analysis section of this opinion, no further project-specific ESA section 7 consultation would be necessary.

Action 7: Salmon eDNA Early Warning

This action, the salmon eDNA early warning action, could improve information used by SaMT and the Delta Monitoring Workgroup for developing salmon risk assessments and water operations recommendations. In particular, this action would improve the ability of these teams to track the presence of migrating juvenile salmon at the point of Delta entry and along the distributary junction leading to the interior and south Delta. This action would be most useful for determining the initial arrival of salmon to the Delta, which triggers Delta Cross Channel gate closures, and the end of salmon presence, signaling the end of the migration season; the function of both triggers is particularly important in drought years.

Exposure: This drought action is not expected to expose or affect NMFS trust resources directly, however a consequence of the action may be an improved measure and management of species presence in the Delta where early detection may allow for more protective actions. Therefore, the exposure to the consequences of this action would be small and limited to the initial juvenile migrant SR winter-run Chinook salmon entering the Delta, as well as the last salmonids to exit the Delta.

Response: The species' response to this action would be dependent on whether additional protective measures were employed because of the increase in detection efficiency. The response to those measures would likely manifest as a small increase in migration success and lifetime spawning success. This action has a small potential impact on individuals because of the current limitations in detection capabilities that are species-specific, not run-specific, which restrict a broader application.

This action does not require any permits, and the sampling protocol can be easily adjusted throughout the monitoring period to respond to environmental conditions. However, currently only species-specific eDNA assays are available, not run-specific assays, limiting its broad application. The action may still be of use if, for example, only SR winter-run Chinook salmon juveniles were expected for a given location and time of year, such that this assay could provide useful data for groups like SaMT and the Delta Monitoring Workgroup in their assessment of species risk. No further project-specific ESA section 7 consultation is necessary.

Action 8: Nimbus Hatchery Drought Preparations

The intended effect of the Nimbus Hatchery drought preparations action is to minimize mortality, decrease the impact of diseases, and meet mitigation goals for production at Nimbus Fish Hatchery during periods of elevated water temperatures. If water reaches lethal temperatures (70°F) at the hatchery, relocating CCV steelhead would avoid a complete loss to the cohort. Because an adequate amount of time is needed to prepare for drought preparations and relocation of CCV steelhead, coordinating early in the season would allow the process to operate more smoothly. If necessary, USFWS, East Bay Municipal Utility District, and NMFS staff will be involved in the coordination and consultation of transporting CCV steelhead out of the Nimbus Fish Hatchery and into a more suitable hatchery.

There are no existing ESA section 7(a)(2) consultations associated with the Nimbus Fish Hatchery facility, but CDFW is in the process of applying for an ESA section 10(a)(1)(A) permit, and, as part of that application, a draft HGMP for Nimbus Hatchery fall-run Chinook salmon is under development.

Exposure: CCV steelhead exposure to the negative effects of this action would be small, but exposure to potential beneficial effects could be large. Exposure is primarily limited to the American River below Nimbus Dam.

Response: Species response to negative effects would be minor to sublethal, including increased straying and potential loss of genetic diversity. The response to beneficial effects would be high, resulting in improved spawning success and increased productivity. NMFS expects the potential for adverse effects associated with this action to be very low, likely occurring in about 4 percent of months (July–April) in critically dry years when modeled temperatures at the hatchery would be above 69.8°F.

This action involves the relocation of fish from the Nimbus Fish Hatchery, which would involve the handling of listed species, therefore incurring direct take of NMFS trust resources. Also, the translocation of fish may lead to increased straying and introgression between populations when adult hatchery fish return to natal streams, which could result in a loss of genetic diversity. Ultimately, these effects will be considered in the ESA section 10(a)(1)(A) permit such that this action will undergo additional ESA section 7 consultation and authorization prior to implementation.

Action 9: Temporary Urgency Change Petition

Reclamation and DWR may jointly submit a TUCP to request that the SWRCB consider modifying requirements of Reclamation's and DWR's water right permits to enable changes in

CVP and SWP operations. Typically, relaxation of water quality or outflow requirements would allow for the reduced delivery of water with reservoir conservation to be used later for instream demands and water quality requirements. The TUCP could modify a combination of D-1641 requirements that ultimately would act to maintain Delta water quality while increasing storage in upstream reservoirs, including Shasta, Folsom, and Oroville.

Exploratory modeling of Reclamation's operations included a proposed action alternative that considered the operational objectives of a TUCP. That modeling scenario was also used as one of a number of scenarios to compare the results of both the IOS life cycle model and the SWFSC's WRLCM analyses of operational scenarios. Although the exact nature of a future application of a TUCP is uncertain, where which particular combination of water quality requirements may be relaxed or not, the IOS and WRLCM analyses describe an overall effect of operations that include an example TUCP.

As would be expected from operational changes that result in increased upstream storage and the relative maintenance of downstream (i.e., riverine and Delta) conditions, Reclamation's IOS modeling showed an increase by 32 percent in mean SR winter-run Chinook salmon egg survival in critical water year types relative to the proposed action (Table 16, Appendix F LCA IOS in U.S. Bureau of Reclamation 2023-2024). Reclamation's IOS modeling also showed that for operations that included a TUCP, the predicted mean SR winter-run Chinook salmon fry survival would increase by 30 percent in critical water year types relative to the proposed action (Table 18, Appendix F LCA IOS in U.S. Bureau of Reclamation 2023-2024). Likewise, WRLCM modeling shows that the mean percent change in freshwater productivity (gulf smolt per spawner) relative to the NAA is 14.22 percent greater for operations of the proposed action with a TUCP (
Table 167).

Table 167. Mean percent change in freshwater productivity (gulf smolt per spawner) relative to the No Action Alternative baseline.

Scenario	Mean % Change in Productivity
ALT2v1_wTUCP	14.22
Alt2v1	2.06
Alt2v2	1.86
EXP3	25.52

Source: WRLCM Report, multi-scenario LTO DRAFT NAA Baseline Hatchery Integrated, May 7, 2024 (QEDA Consulting LLC 2024)

Exposure: This action has the potential to expose all species and life stages such that exposure is considered high.

Response: The primary mechanism for effects related to this action will be a relaxing of downstream demands, decreasing river flows while maintaining water quality, which will allow for increased retention and storage of water in the winter and spring seasons. The additional reservoir storage will then provide for improved conditions (i.e., temperatures and flow) in the summer and fall. Species response to the decrease in flows is expected to be minor, affecting juvenile migration success and productivity. The response to the beneficial effects of increased storage, cold water pool volume, and improved summer/fall temperatures would be an increase in spawning success and egg survival, thereby improving the productivity of the subsequent brood year. The potential for adverse impacts associated with this action is expected to be small, as its implementation may be considered in more extreme cases of drought (i.e., 8.5 percent of years identified as "Bin 3").

This action, the need to request a TUCP, would be considered during Reclamation's annual forecast and water contract allocation processes, as well as the interagency development of a drought contingency plan. Given the positive direction of species response as indicated by the life cycle modeling analyses and the expectation of further review and coordination of this action as part of the governance processes of annual SHOT and WOMT planning necessary to achieve the nondiscretionary water quality requirements discussed in the Environmental Baseline section of this opinion, no additional ESA section 7 consultation would be necessary.

Action 10: Emergency Drought Salinity Barrier

Reclamation and DWR may consider the installation of an emergency drought salinity barrier made of embankment rock across West False River from Jersey Island to Bradford Island in Contra Costa County. The project is intended to protect the beneficial uses of water in the Central and South Delta during drought periods by reducing the intrusion of saltwater from the Bay. This action is consistent with the State's long-term strategic plan for managing water resources throughout the state of California. With the TUCP order relaxing some D-1641 requirements and the emergency drought salinity barrier in place, interior Delta salinity will be maintained with the release of less fresh water from upstream reservoirs, including Shasta and Oroville.

Exposure: Exposure to potential beneficial effects could be large, affecting upstream reservoir operations and multiple species and life stages.

Response: The species' response to negative effects would be minor to potentially lethal, affecting migration success and survival. Response to the beneficial effects is expected to be high, increasing reservoir storage, cold water pool volume, and improving summer/fall temperatures, which in turn will increase spawning success and egg survival, improving species productivity. The potential for adverse impacts associated with this action is expected to be small, as its implementation may be considered in the more extreme cases of drought (i.e., 8.5 percent of years identified as "Bin 3" or drought periods lasting longer than a single year).

Ultimately, these effects will be considered in a subsequent project-specific ESA section 7 consultation and take authorization.

Action 11: Curtailments

This action, the exercising of water right curtailments, would protect lawful diversions of water (including protecting previously stored water not available for diversion) and the Delta ecosystem by prohibiting water diversions when water is not available at water right holders' or claimants' priority of right. If necessary, the SWRCB may adopt emergency curtailment regulations pursuant to the directive of the Governor's emergency drought proclamation. Emergency regulations may allow for curtailment orders that direct water right holders to stop diverting, including under pre-1914 appropriative or riparian claims. This action is intended to reduce river flow depletions downstream of reservoirs, which will leave water in storage or in river channels to support ecosystem functions and to serve downstream lawful diversions of water and avoid depleting reservoirs.

Exposure: This action has the potential to expose all species and life stages such that exposure is considered high.

Response: The primary mechanism for effects related to this action will be a reduction in diversions and downstream demands, which may result in lower reservoir releases and river flows in the upper watersheds above the points of diversion and a commensurate increase in reservoir storage. The additional reservoir storage could provide for an improved ability to manage conditions (i.e., temperatures and flow) in the summer and fall. Species response to the decrease in flows is expected to be minor, affecting juvenile migration success and productivity. The response to the beneficial effects of increased storage, cold water pool volume, and improved temperature management would be an increase in spawning success and egg survival, thereby improving the productivity of the subsequent brood year. The potential for adverse effects associated with this action is expected to be small, as its implementation may be considered in more extreme cases of drought (i.e., 8.5 percent of years identified as "Bin 3" or drought periods lasting longer than a single year).

This action would be considered during Reclamation's annual forecast and water contract allocation processes as well as part of the interagency development of a drought contingency plan pursuant to a Governor's emergency drought proclamation. Given the expectation of a positive species response and the expectation of further review and coordination of this action that is considered part of the governance processes of annual SHOT and WOMT planning, no further project-specific ESA section 7 consultation would be necessary.

Action 12: Emergency Clear Creek Pulse Flow

Through this action, Reclamation would release an emergency pulse flow with the intent of triggering the upstream movement of CV spring-run Chinook salmon (using flow and temperature as migration cues/triggers). As there is no water allocated for an emergency pulse during drought conditions, base flows would be reduced, commensurate with the pulse volume, so that no additional water is needed beyond normal operations (i.e., proposed action minimum flows).

Exposure: This action would expose a large proportion of the adult CV spring-run Chinook salmon and CCV steelhead populations returning to Clear Creek to increased flows.

Response: The intended effect of the emergency pulse would be to encourage CV spring-run Chinook salmon to migrate further upstream, above the Gorge Cascade. The species response would be for these fish to make their way into the upper reach of Clear Creek, where they could hold in the deep pools and cool water of the canyon and be protected from poaching and fall-run Chinook salmon interaction impacts. Ultimately, this action would result in increased spawning success contributing to increased productivity. The potential for adverse effects associated with this action is considered small, as its previous implementation was an exception and future application would likely only be considered in a small fraction of years, perhaps coincident with the 20 percent of years identified as "Bin 2B" or "Bin 3."

This action, the emergency Clear Creek pulse flow, would be considered when the CCTT establishes the shaping and timing of flows released from Whiskeytown Dam to optimize biological benefits downstream. Given the further review and coordination of this action that is considered part of the governance processes of CCTT and SHOT planning as discussed in the Clear Creek Division effects analysis section of this opinion, no further project-specific ESA section 7 consultation would be necessary.

Action 13: Infrastructure Improvements at Livingston Stone National Fish Hatchery

This action, the long-term infrastructure improvements at LSNFH, will increase the SR winter-run Chinook salmon production potential through the improvements and additions of infrastructure to LSNFH. Reclamation is currently identifying facility alternatives to address aging infrastructure, reliability concerns, and upgrades required to meet current and future production obligations at LSNFH, located at the base of Shasta Dam on the Sacramento River. The hatchery was constructed in 1997 as a temporary facility to support the conservation of SR winter-run Chinook salmon. Record droughts and lethal water temperatures have compromised in-river survival and the ability to efficiently and effectively operate LSNFH. Programmatic needs have evolved from a modestly scaled, temporary annual supplementation of the naturally spawning population to relying on the facility as a primary method to prevent extinction, including substantially increased production during years of drought and maintenance of a captive broodstock program (National Marine Fisheries Service 2017c).

Exposure: The exposure to the negative effects of this action is expected to affect the hatchery-reared proportion (medium) of a single cohort of SR winter-run Chinook salmon. The long-term, beneficial effects are also expected to have broad exposure affecting a medium proportion of multiple cohorts.

Response: The response to negative effects would be sublethal to lethal, decreasing spawning success or increasing egg mortality. Conversely, the response to beneficial effects would be high, increasing spawning success and reducing egg mortality. The action is already underway, but the potential for adverse effects associated with the potential negative impacts would be low and limited to a single cohort. However, the potential for beneficial effects of the infrastructure improvements would be high, affecting multiple cohorts into the future.

The initial steps of scoping this action are already underway, and there will be further consultation prior to the construction and operation of the new facility. Ultimately, the benefit of this action, the improved ability to meet annual and emergency production targets under hatchery

best management practices, will be the subject of a project-specific ESA section 7 consultation and take authorization.

Action 14: Lower Pump Intakes Near Wilkins Slough

This action would lower the irrigation pump intakes at Meridian Farms so as to increase Reclamation's flexibility to operate Shasta Reservoir in a manner that meets other requirements, namely cold-water pool management. The Meridian Farms irrigation pump intakes will be lowered to ensure they remain operational at Sacramento River flows below 5,000 cfs. The installation of lower irrigation pump intakes will include fish screens that meet California and NMFS requirements, structural improvements, and landside improvements. It will also specifically include relocating and merging the Drexler pumping plant facility. Furthermore, additional facilities in the vicinity will be considered by the Small Pump Screening Program. This change will increase flexibility in the operation of Shasta Reservoir at flows below 5,000 cfs at Wilkins Slough.

Exposure: The species exposure to negative effects are expected to be temporary, small, and limited to a single cohort during a NMFS-approved in-water work window. Exposure to the potential beneficial effects could be large, spanning multiple cohorts of juvenile fish.

Response: The species response to the negative effects of in-water construction would be minor delays in migration to potentially lethal. The species' response to the beneficial effects of screening water diversions would be high, improving the function of the water diversion while also reducing the potential entrainment of juvenile fish. The potential for adverse effects associated with this action would be low, likely occurring in a single year. However, once properly screened, the frequency of Reclamation operating to flows at Wilkins Slough of less than 5,000 cfs would be about 20 percent of years identified as "Bin 2B" or "Bin 3."

This action involves in-water construction at and around the Meridian Farm pumps within the Sacramento River, which would negatively affect the critical habitat of NMFS trust resources. Also, depending on the timing of construction activities, the in-water construction could directly harm fish species, including NMFS trust resources. Ultimately, these effects will be considered in a project-specific ESA section 7 consultation and take authorization prior to implementation.

Action 15: Installation of the Shasta Temperature Control Device Middle Gate Curtain

Under this action, Reclamation would deploy the Shasta Reservoir temperature control device middle gate curtain. This work requires divers to release a rolled-up impermeable curtain over the middle temperature control device gates to block water from entering the temperature control device at the middle gate elevation and limit warm water leakage. The intent is to improve seasonal temperatures downstream of Keswick Dam and reduce late-season TDM risk.

Exposure: This action is not expected to expose species to any of the action's effects. The indirect exposure of this action, which will allow for the more precise, targeted release of water at a particular temperature and thereby make temperature management more effective, will expose a large proportion of the SR winter-run Chinook salmon to improved temperature control.

Response: Species response to the marginal difference in downstream temperature is expected to be small. The potential for adverse effects associated with this action is considered small, as its implementation may be considered in about 20 percent of years identified as "Bin 2B" or "Bin 3."

This action, the installation of the Shasta temperature control device middle gate curtain, could be considered during Reclamation's annual forecast and water contract allocation processes, as well as the interagency development of the Shasta Management Plan. Given the further review and coordination of this action that is considered part of the governance processes of annual SRG and SHOT planning and real-time operations discussed in the Sacramento River Division effects analysis section of this opinion, no project-specific ESA section 7 consultation would be necessary.

Action 16: Aquatic Vegetation Monitoring

Invasive floating aquatic vegetation and submerged aquatic vegetation cause navigation hazards in the Delta and decrease habitat for listed fish species. Floating aquatic vegetation and submerged aquatic vegetation have increased in coverage over the past 20 years, with particular increases seen in the last drought. Both types of vegetation establish more readily in slower-moving water, so low flow conditions that occur during droughts have been linked to increases in coverage of invasive vegetation.

This action includes monitoring of invasive aquatic vegetation in the Delta and Suisun Marsh, with respect to the decreased outflow and increased temperatures that occur during droughts. The action is intended to help assess the impact of drought and help to inform control strategies if drought continues. Specifically, this action would track any expansion of weeds resulting from decreased flow, prioritize areas for weed treatment/control, assess the impacts of other drought response actions, and evaluate the effectiveness of restoration sites.

Exposure: This action is not expected to expose species to any of the action's effects.

Response: No specific species response associated with the monitoring of aquatic vegetation is expected. As a drought toolkit action, the potential for adverse effects associated with its implementation is considered small, as it may be considered in about 20 percent of years identified as "Bin 2B" or "Bin 3."

This action would not require changes to water operations, nor would it require additional permitting, as sampling protocol is not likely to affect listed species and may be adjusted throughout the monitoring period to respond to environmental conditions. Furthermore, this action collects important data on environmental impacts of drought that would be useful to multiple federal and state agencies (NMFS, USFWS, Reclamation, CDFW, DWR, and the California Division of Boating and Waterways). These data can also be used to evaluate the impacts of fall flow actions on weeds and can be used to inform Delta plan performance measures, specifically Outcome Performance Measure 4.10, Terrestrial and Aquatic Invasive Species. Because this action would not affect species, no project-specific ESA section 7 consultation would be necessary.

Action 17: Delta Ecosystem Monitoring and Synthesis

Through this action, DWR has led a team of Interagency Ecological Program scientists to develop a monitoring and synthesis plan for the environmental impacts of drought and drought actions in the Delta and Suisun Marsh. Future applications of the Delta ecosystem monitoring and synthesis action could apply a similar framework for monitoring and evaluation. Data collection would rely primarily on existing monitoring, with the addition of a few special studies, such as aquatic vegetation monitoring (Drought Toolkit action 16). Data will be integrated and compared to previous drought and wet periods to detect relative ecosystem changes. These changes will also be compared to actions in the Drought Toolkit to inform future dry-year actions.

Exposure: This action is not expected to expose any species to the action.

Response: No specific species response associated with the monitoring and synthesis of drought effects is expected. However, the effect of the synthesis report could improve the management of the ecosystem and, therefore, provide a benefit to the species. As a drought toolkit action, there is no exposure nor response; therefore, there would not be any associated potential for adverse effects.

The future application of this action would improve understanding of the environmental impacts of drought, provide a means to assess the environmental effects of actions included in the Drought Toolkit, and develop recommendations for future drought response. This action would not require changes to water operations, nor would it require additional permitting, as sampling is not likely to affect listed species beyond what is authorized in the Delta monitoring ESA section 10(a)(1)(A) permits. Because this action would not affect species beyond what has been considered in existing monitoring permits but could be leveraged to inform the assessment of Drought effects and future Drought Toolkit actions as discussed in the approach to Governance described in the proposed action (U.S. Bureau of Reclamation 2023-2024), a project-specific ESA section 7 consultation and authorization would not be necessary.

Action 18: Increased Production at Livingston Stone National Fish Hatchery

This action would activate contingency operations at LSNFH to increase the adult collections and the juvenile production of SR winter-run Chinook salmon beyond the typical goals. The current LSNFH HGMP can accommodate increased production such that a maximum number of adults to be collected for broodstock under expanded production is 400 (normal broodstock collection levels are 60 females and 120 males).

This take is shared with the Battle Creek Jumpstart Project, which is expected to collect up to 100 adults for broodstock annually, thus reducing the take available for expanded production years down to 200. The existing ESA section 10(a)(1)(A) permit may also be modified to increase collection and production levels, however, to do so would require further review and consultation.

Exposure: Species exposure to the negative effects would be small, related to increased capture and handling of hatchery broodstock, but also large for the potential loss of genetic diversity. The exposure to potential beneficial effects would be large.

Response: The response to the negative effects, capture, and handling would be lethal, and the loss of genetic diversity would be expected to be sub-lethal. Species response to the beneficial effects would be high, increasing spawning success, productivity, and effective population size. The potential for adverse effects associated with this action is considered low, likely occurring in about 8.5 percent of years identified as "Bin 3."

This action involves the increased capture of fish from the Sacramento River, which would involve the handling of listed species, incurring direct take of NMFS trust resources. This take is authorized in the existing ESA section 10(a)(1)(A) permit and HGMP for LSNFH. Because this action would not affect species beyond what has been considered in existing permits, and given the further review and coordination of this action that is considered part of the governance processes of annual SRG and SHOT planning as discussed in the Sacramento River Division effects analysis section (Section 7.1) of this opinion, no project specific ESA section 7 consultation would be necessary. However, if through the SRG and SHOT coordination, it was determined that hatchery collection and production would be necessary to avoid catastrophic population decline, the hatchery ESA section 10(a)(1)(A) permit may be modified. If a modification to the permit is necessary, this action will undergo additional ESA section 7 consultation and authorization prior to implementation.

Action 19: Drought Feather River Spring Flow Redistribution

This action would reallocate flow from the Feather River high-flow channel to the Feather River low-flow channel so as to attract listed CV spring-run Chinook salmon into the FRFH. Increased attraction of fish to the hatchery would facilitate marking broodstock for fall spawning. Potential benefits in addition to the increased attraction include increased CV spring-run Chinook salmon over-summering in the low-flow channel, which offers better over-summer holding temperatures and refuge from recreational angler harvest.

Under current water operations, the volume of flow entering the Feather River from the Thermalito Afterbay Outlet is significantly greater than the flow entering this junction from the upstream low-flow channel. This induces CV spring-run Chinook salmon to hold in the Thermalito Afterbay Outlet rather than move upstream through the low-flow channel into the FRFH where they can be tagged and subsequently utilized as spawning broodstock. Increasing the flow distribution through the low-flow channel has proven to be effective in attracting CV spring-run Chinook salmon upstream into the low-flow channel and, subsequently, the FRFH. Once at the hatchery, CDFW tags CV spring-run Chinook salmon broodstock as they enter in the spring and early summer, then releases these tagged fish to over-summer in the Feather River. This is done to ensure that during the fall spawn pairings at FRFH occur between CV spring-run Chinook salmon and do not include later arriving fall-run Chinook salmon. Entry into the FRFH would also provide an opportunity to treat these fish with thiamine hydroxyzine hydrochloride to address thiamine deficiency issues. Lastly, the attraction of CV spring-run Chinook salmon adults to the low-flow channel increases the likelihood that CV spring-run Chinook salmon will over-summer in the cooler temperatures of the low-flow channel where recreational angling is prohibited, decreasing the likelihood that CV spring-run Chinook salmon would be subjected to recreational angling harvest in the waters below the Thermalito Afterbay Outlet.

Exposure: Exposure of the Feather River population of CV spring-run Chinook salmon to the potential beneficial effects of the action would be medium for that population.

Response: Species response is expected to be beneficial, where the magnitude of effects would be high, resulting in an increase in spawning success and survival. The potential for adverse effects associated with this action is expected to be low, likely occurring in critically dry water year types or in years with continuing drought conditions.

This action, drought Feather River spring flow redistribution, is separate from the actions covered by the LTO ESA section 7 consultations and California Endangered Species Act ITP.

Action 20: Folsom Dam Power Bypass

Through this action, Reclamation would consider a power bypass at Folsom Dam to access Folsom Reservoir's cold-water pool that resides below the Folsom power unit intakes. The reservoir's cold-water pool is a finite resource that is carefully managed across the year. A Folsom Dam power bypass reduces the amount of hydroelectric power generation because this water is not released through the powerplant and CVP power customers must then seek replacement power. This management decision is informed by modeling that helps indicate potential temperature benefits to the Lower American River and subsequent benefits to Lower American River fish species and is weighed against Folsom Dam operational risks and the economic cost of lost power generation. The power bypass is usually implemented sometime in mid-to-late October through early November.

Exposure: Based on the expected timing of the power bypass, the listed species and life stages exposed to decreased river temperatures as a result of this Drought Toolkit action include: a medium proportion of CCV steelhead eggs incubating in the American River, a medium proportion of adult CCV steelhead holding before spawning, and a large proportion of rearing juvenile CCV steelhead.

Response: The egg life stage is the most temperature-sensitive, but relatively few (but possibly greater than 2 percent of the year-class's spawning) will be present in late October and early November. Holding adult and rearing juvenile CCV steelhead will also benefit from the temperature decreases, though the decreases are likely to be relatively small and short in duration. Individual response is expected to result in a small reduction in temperature-induced egg mortality and reduced stress on holding adults and rearing juveniles, leading to increased spawning success and survival.

Although considered in many years, the potential for adverse effects associated with this action being implemented is expected to be low, likely occurring in critically dry water year types or in years with continuing drought conditions.

This action, the Folsom Dam power bypass, would provide greater flexibility in meeting Lower American River temperature targets and preserving a cold-water pool, which would, in turn, provide for temperatures that are supportive of species. Although it is very unlikely that this action would negatively affect species, using the lower outlets would bypass the power plant, removing the ability to generate power from reservoir releases. Given that the potential risk of negative effects to species and habitat, and that the decision whether to implement this action would only be made following American River Group discussions on power bypass, Reclamation's California Great-Basin Regional Director approval, and Reclamation alerts to power customers of the potential bypass and briefs them of the bypass analysis as discussed in

the American River Division effects analysis section of this opinion, no project-specific ESA section 7 consultation would be necessary.

Action 21: Harmful Algal Bloom Monitoring

This action includes monitoring the response of harmful algal blooms in the Delta and Suisun Bay resulting from decreased outflow, increased salinity, and increased water temperatures that occur in droughts. Harmful algal blooms are formed by photosynthetic plankton that can produce nerve, muscle, respiratory, and liver toxins affecting aquatic organisms, wildlife, and humans. Harmful algal blooms can occur in fresh, brackish, and marine waters in an estuary. Harmful algal blooms have increased in the number of plankton species and types of toxins across the San Francisco Estuary for the past 20 years. To track the impact of drought on harmful algal blooms, existing monitoring programs would document the absence or presence of harmful algal blooms from a standard visual ranking colonial scale. The intent of this action is to track the development and possible expansion of harmful algal blooms resulting from decreased flow, increased water temperatures, and other possible water quality changes and assess the impacts of other drought actions (e.g., temporary barriers). This action will help assess the impact of other Drought Toolkit Actions, including Delta outflow and temporary barriers, as well as plan mitigation strategies if drought continues.

Exposure: This action is not expected to expose species to any of the consequences of the action.

Response: No specific species response associated with the monitoring of harmful algal blooms is expected. As a drought toolkit action, there is no exposure nor response, therefore there would not be any potential adverse effects associated with the action.

This action would not require changes to water operations, nor would it require additional permitting, as remote sampling is not likely to affect listed species. Furthermore, this action collects data on the environmental impacts of drought that would be useful to interagency collaborative groups assessing the condition of the Delta (e.g., SaMT and the Delta Monitoring Workgroup). These data can also be used to evaluate the influence of other Drought Toolkit actions as to their synergistic effects on decreased flow, increased water temperatures, and other possible water quality changes. Because this action would not affect species, a project-specific ESA section 7 consultation is not necessary.

Action 22: Translocation of Naturally Spawning Sacramento River Chinook Salmon

This action is an emergency effort to translocate SR winter-run and CV spring-run Chinook salmon out of the Sacramento River because of elevated warmer temperatures and into cooler, suitable habitats. Adult SR winter-run and CV spring-run Chinook salmon would be translocated only when LSNFH capacity is maximized, Shasta and Trinity reservoir levels are low, and drought conditions persist. Once approval of the translocation is finalized, adult SR winter-run and CV spring-run Chinook salmon would be trapped at Keswick Dam and the Coleman National Fish Hatchery and translocated from the Upper Sacramento River into Battle Creek and Clear Creek.

Translocation would be conducted only as an extreme measure, providing an increased opportunity for successful egg incubation and juvenile survival with the intended outcome to avoid the near 100 percent temperature-related mortality of eggs if adults spawn in the Sacramento River. This emergency action would accelerate the reintroduction of SR winter-run Chinook salmon into Battle Creek and provide increased survival opportunities for the Sacramento River population. The translocation of Sacramento River CV spring-run Chinook salmon to Clear Creek, where a small, dependent population exists, would also create an opportunity for successful spawning of CV spring-run Chinook salmon adults. This action would be a positive contribution to an ESU under an increased threat of climate change and drought conditions.

Exposure: The exposure to the negative effects of this action would be small and limited to those fish captured and relocated. The exposure to potential beneficial effects could be large, as relocated fish will have an improved opportunity to contribute to the population.

Response: Species response to negative effects would be minor to sublethal, related to capture and handling. The beneficial response is uncertain but could be high, leading to increased spawning success and productivity. Effects associated with taking this action would likely occur in at most 8.5 percent of years identified as "Bin 3." This action involves the relocation of fish from the Sacramento River, which would involve the handling of listed species, incurring direct take of NMFS trust resources. Also, the translocation of fish may lead to increased straying and introgression between populations when adult fish return to natal streams, which could affect a population's genetic diversity. However, these effects would only manifest years after successful translocation, without which the source population is likely to experience near 100 percent mortality. This action will undergo project-specific ESA section 7 consultation and authorization prior to implementation.

Action 23: Relocation of Central Valley Spring-Run Chinook Salmon Collected Incidentally at the Keswick Dam Fish Trap to Clear Creek

Similar to Drought Toolkit action 22, this action, the relocation of CV spring-run Chinook salmon collected incidentally at the Keswick Dam fish trap to Clear Creek, is intended to mitigate the effects associated with poor spawning conditions in the mainstem Sacramento River. The intended effect of this action is to provide access to thermal refugia in the upper reach of Clear Creek for CV spring-run Chinook salmon captured incidentally in the Keswick Dam fish trap. Rather than release them back to the Sacramento River, where summer and fall temperatures may become unfavorable because of the depletion of the Shasta Reservoir cold water pool, CDFW would translocate incidentally captured CV spring-run Chinook salmon to the tailwater release of Whiskeytown Dam in Clear Creek. There, water temperatures are expected to be less detrimental than in the mainstem Sacramento River at that time of year.

Exposure: The exposure to the negative effects of this action would be small and limited to those fish captured and relocated. The exposure to potential beneficial effects could be large, as relocated fish will have an improved opportunity to contribute to the population.

Response: Species response to negative effects would be minor to sublethal, related to capture and handling. The beneficial response is uncertain but could be high, related to increased

spawning success and productivity. Potential adverse effects associated with taking this action are considered low, likely occurring in at most 8.5 percent of years identified as “Bin 3.”

This action involves the translocation of fish from the Sacramento River to Clear Creek, which would involve the handling of listed species, incurring direct take of NMFS trust resources. Also, the translocation of fish may lead to increased straying and introgression between populations when adult fish return to Clear Creek, which could affect both populations' genetic diversity. However, these effects would only manifest years after successful translocation, without which the source population would experience a very high degree of mortality. This action will undergo project-specific ESA section 7 consultation and authorization prior to implementation.

Action 24: Relocation of Adult Sacramento River Winter-Run Chinook Salmon Trapped at Coleman National Fish Hatchery and the Keswick Dam Fish Trap to Battle Creek, Upstream of Eagle Canyon Dam

Similar to Drought Toolkit action 22, this action, the relocation of adult SR winter-run Chinook salmon trapped at Coleman National Fish Hatchery and the Keswick Dam fish trap to Battle Creek upstream of Eagle Canyon Dam, is intended to mitigate the risk associated with poor spawning conditions in the mainstem Sacramento River. This action would be taken to improve the reproductive success of SR winter-run Chinook salmon that would have otherwise spawned in potentially unsuitable water temperatures in the Sacramento River and downstream of Eagle Canyon Dam in Battle Creek. Moving a portion of adult SR winter-run Chinook salmon from the Sacramento River to the upper reaches of North Fork Battle Creek would contribute to the Battle Creek reintroduction effort already underway and provide those adults with more suitable water temperatures for spawning.

Exposure: The exposure to the negative effects of this action would be small and limited to those fish captured and relocated. The exposure to potential beneficial effects could be large, as relocated fish will have an improved opportunity to contribute to the population.

Response: Species response to negative effects would be minor to sublethal, related to capture and handling. The beneficial response is uncertain, but could be high, related to increased spawning success and productivity. The effects associated with taking this action would likely occur in, at most, 8.5 percent of years identified as “Bin 3.”

This action involves the translocation of fish from the Sacramento River and Lower Battle Creek to Battle Creek above Eagle Canyon Dam, which would involve the handling of listed species, incurring direct take of NMFS trust resources. Also, the translocation of fish may lead to increased straying and introgression between populations when adult fish return to Battle Creek, which could affect both populations' genetic diversity. However, these effects would only manifest years after successful translocation, without which the source population would experience a very high degree of mortality. This action will undergo project-specific ESA section 7 consultation and authorization prior to implementation.

Action 25: Incubate a Portion of Sacramento River Winter-Run Chinook Salmon Eggs from Livingston Stone National Fish Hatchery Along the McCloud River

This action would continue a pilot project implemented in 2022 and developed by the CDFW, Winnemem Wintu Tribe, NMFS, and USFWS, where approximately 40,000 salmon eggs from LSNFH were incubated in remote site incubators at a site on the McCloud River. The intent of the McCloud action is to reduce the risk facing SR winter-run Chinook salmon in the Upper Sacramento River. Specifically, the purposes of this action are to (1) provide an additional SR winter-run Chinook salmon egg incubation and rearing location to reduce the risk of adverse impacts to early life stages caused by extreme drought, (2) collect information on the remote site incubator system and rotary screw traps as a means to inform future SR winter-run Chinook salmon recovery actions on the McCloud River, and (3) study juvenile SR winter-run Chinook salmon growth, survival, and out-migration timing in their historical habitat to inform long-term recovery planning.

Exposure: The exposure to the negative effects of this action would be small and limited to those fish captured and handled. The exposure to potential beneficial effects could be large, as hatchery-produced eggs will have improved survival and will contribute to an expansion of the population.

Response: Species response to negative effects would be minor to sublethal, related to capture and handling. The long-term beneficial response is uncertain but could be high, related to increased spawning success, productivity, and spatial structure. Initially, the potential associated with this action is considered minor, only occurring in the 8.5 percent of years identified as "Bin 3."

This action involves the relocation of SR winter-run Chinook salmon eggs from the LSNFH to the McCloud River and the downstream capture and transport of juvenile fry, which involves the handling of listed species, incurring direct take of NMFS trust resources. However, these actions are intended to address extreme drought conditions when LSNFH is at maximum capacity and production is thereby limited by available egg incubation and fry-rearing facilities. This action will undergo project-specific ESA section 7 consultation and authorization prior to implementation.

7.9.4. Monitoring

Reclamation and DWR propose a framework programmatic approach to address potential future changes to ongoing monitoring programs and activities. Many ongoing monitoring programs that inform operational actions and effects are currently under existing and separate ESA section 7 consultations and section 10(a)(1)(A) permits and considered in the Environmental Baseline section of this opinion. Potential future changes to monitoring programs associated with the operation of the CVP and SWP will be addressed in separate ESA section 7 consultations that are tiered to the consultation. Subsequent changes to existing monitoring programs would be coordinated and included in future consultations of the LTO of the CVP and SWP to allow for a more uniform analysis and improved accounting of incidental take coverage associated with the operation of the CVP and SWP.

The framework programmatic consultation approach for monitoring includes the following principles, which would be incorporated into any future changes to monitoring programs addressed in a subsequent consultation:

- Ensure monitoring will be beneficial to the LTO of the CVP and SWP for:
    - Minimizing effects to listed species and habitat (informing real-time operations, understanding species status, etc.)
    - Understanding if various operational objectives are met (e.g., effectiveness and validation monitoring)
    - Measuring if and when the reinitiation trigger associated with the amount or extent of incidental take has been met
- Confirm that the data collected should meet data quality objectives and open data practices
- Establish a multi-agency collaborative approach, including a management structure for decision-making
- Ensure scientific rigor of new or modified monitoring and achieving objectives of new or modified monitoring
- Develop and test mechanisms for learning and adopting new technologies, while maintaining comparability and continuity to historical information on fish and the environment
- Incorporate a fish, aquatic habitat, and ecosystem monitoring enterprise for the LTO of the CVP and SWP that should effectively measure physical conditions; water quality; primary and secondary production; abundance, distribution, and production of ESA-listed species (natural and hatchery origin); Delta and tributary fish assemblages; and salvage at the CVP and SWP fish collection facilities
- Establish mechanisms for close coordination with any existing or future AMP
- Provide for robust synthesis of monitoring data to incorporate results and lessons learned

Given the framework-level programmatic nature of this action component, where further commitment and collaborative planning are necessary to identify effects and quantify a level of benefits and incidental take, it is still possible to estimate a general level of impact qualitatively.

Monitoring effects to listed species commonly include sublethal and lethal effects associated with the capture, collecting, and handling of individuals, although some monitoring activities involve passive techniques that do not result in any adverse effects, and these effects are analyzed in the Environmental Baseline section of the BA (U.S. Bureau of Reclamation 2023-2024) and in this opinion. Future, potential changes to existing monitoring programs are not known at this time, and the detailed effects of potential changes are not known and would be speculative at this time. Information about when, where, and how the monitoring will occur is important to determining the extent, frequency, and duration of adverse effects, if any, to listed species and critical habitat. If there are changes to the monitoring programs, subsequent approvals would likely be required through separate tiered or stepped-down consultations if it is determined that those activities may affect listed species or designated critical habitat. In general, the objectives of the monitoring program are consistent with operational objectives of the long-term operation of the CVP and SWP.

7.9.5. Tidal Habitat Restoration

Reclamation and DWR proposed to restore 5,677 acres of tidal habitat, completing the remainder of the 8,396.3 acres of tidal habitat restoration identified from the 2008 and 2019 USFWS biological opinions (8,000 acres for Delta smelt) and the 2020 CDFW ITP (396.3 acres for longfin smelt). All 12 current and future restoration projects (totaling 8,396.3 acres) are located in the northern arc of the upper estuary (area of highest Delta smelt occupation) and are designed to enhance habitat for both species, including food production and rearing habitat. Reclamation and DWR will complete restoration requirements by 2026. This element of the proposed action is considered here, in the Framework Programmatic section, because project-specific consultation will determine the amount and extent of take associated with these restoration projects. Furthermore, the impact and effectiveness of these projects will be assessed as part of the LTO AMP discussed below.

All ESA-listed salmonids and green sturgeon must pass through the Delta during their migration to the Pacific Ocean. Although rearing and migration through the Delta represents a short period of these fish's overall life cycle, a large proportion of juvenile SR winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon are expected to be exposed to the tidal habitat restoration in the Delta.

Habitat restoration is expected to benefit juvenile SR winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon through increased food availability and quality and refuge habitat from predators. These benefits can be manifested by higher growth rates in fish utilizing these habitats and increased survival through the Delta.

The following life stages of the listed salmonids and sDPS green sturgeon are expected to be present in the Delta during this period and have the potential to be exposed to impacts from in-water construction: immigrating adult CCV steelhead, juvenile sDPS green sturgeon, and some emigrating adult sDPS green sturgeon. Few, if any, juvenile SR winter-run Chinook salmon, CV spring-run Chinook salmon, or CCV steelhead are expected to be present during the in-water construction work window.

Anticipated effects during construction include temporary loss of aquatic and riparian habitat leading to increased predation, increased water temperature, and reduced food availability; degraded water quality from contaminant discharge by heavy equipment, soils, and increased discharges of suspended solids and turbidity leading to direct toxicological impacts on fish health/performance, indirect impairment of aquatic ecosystem productivity, loss of aquatic vegetation providing physical shelter, and reduced foraging ability caused by decreased visibility; impediments and delay in migration caused by elevated noise levels from machinery; and direct injury or mortality from in-water equipment strikes or isolation/stranding within dewatered cofferdams. The risk from these potential effects would be minimized through the application of avoidance and minimization measures. In general, the objectives of tidal habitat restoration are consistent with operational objectives of the long-term operation of the CVP and SWP.

7.9.6. Adaptive Management Actions and Special Studies

The AMP and Special Studies are considered in this opinion as a framework programmatic action. The AMP is described in Appendix X of the BA (U.S. Bureau of Reclamation 2023-2024) and explains how the AMP process works and links to the operations of the CVP and SWP. The AMP will be utilized by Reclamation, DWR, CDFW, USFWS, and NMFS to inform the LTO and activities of the CVP and SWP. The AMP will establish an AMSC to coordinate through individual Adaptive Management Teams responsible for evaluating each Adaptive Management Action, utilizing decision support tools such as structured decision-making to improve future management decisions to improve the operations of the CVP and SWP for project purposes. The AMP includes a list of actions and programs from the proposed action, along with details regarding the timeframe of evaluation of each action and the Adaptive Management Team(s) responsible for implementing them. The objectives of the AMP are consistent with operational objectives of the long-term operation of the CVP and SWP. The AMP actions described in Appendix X of the BA (U.S. Bureau of Reclamation 2023-2024) include:

- SR Winter-run Chinook Salmon OMR Management
- CV Spring-run Chinook Salmon OMR Management
- Summer-Fall Habitat Action for Delta Smelt
- Tidal Habitat Restoration Effectiveness for Smelt Fishes
- Tributary Habitat Restoration Effectiveness for Salmonid Fishes
- Shasta Spring Pulse Flow Studies
- SR Winter-run Chinook Salmon Through Delta Survival Targets
- Longfin Smelt Science Plan Actions
- Delta Smelt Supplementation
- CCV Steelhead JPE
- Alternative Salmonid Loss Estimation Pilot Study
- Shasta Cold Water Pool Management
- Georgiana Slough Migratory Barrier Effectiveness for Salmonid Fishes
- Spring Outflow
- Clear Creek
- Steelhead Telemetry Research
- Steelhead Life Cycle Monitoring
- CV Spring-run Chinook Salmon JPE and Life Cycle Model
- SR Winter-run Chinook Salmon Life Stage Studies
- Delta Route Selection and Survival
- Longfin Smelt Science Plan
- Longfin Smelt Science and Monitoring Initiatives
- Management of SR Winter-run Chinook Salmon Spawning Location and Timing

At the time of this consultation, there are 23 Adaptive Management Actions and Special Studies that are proposed; however, more may be added as new approaches and actions are developed to address changing conditions and new science. Prior to the implementation of some of these actions, there will be further analysis or consultation to quantify a level of effect and provide ESA take authorization if necessary (Table 166). NMFS here provides a qualitative assessment of the exposure and response of each Adaptive Management Action and Special Study so as to provide a basis of understanding and ensure that they would not increase the likelihood that the

proposed action could jeopardize the continued existence of endangered or threatened species or destroy or adversely modify their designated critical habitat.

With the AMP, new information obtained during the course of implementation is expected to inform future operational decisions and approaches to protecting listed species and critical habitat. New information will be developed through special studies and scientific research, and as those studies are developed, more information will inform the amount or extent of potential impacts Therefore, the BA (U.S. Bureau of Reclamation 2023-2024) and this opinion do not analyze how or if activities associated with adaptive management would affect listed species or designated critical habitat. Addressing effects resulting from the implementation of the AMP would be speculative at this time. The AMP and associated agreement and schedule do, however, commit the implementing agencies to a process, and as actions are moved through that process, Reclamation and DWR will evaluate the scope of effects and work with NMFS to determine if the scope of effects are not analyzed in this opinion. If not, and the activities are not subject to subsequent consultation under ESA section 7, then separate tiered or stepped-down consultations will occur to address those effects and authorize either the studies or operational changes that result.

Adaptive Management Actions are categorized into three bins:

- Bin 1: Evaluation occurs annually to biannually by technical teams
- Bin 2: Evaluation and potential refinement occurs within the timeframe of the biological opinions and ITP
- Bin 3: Evaluation and potential refinement occur in a longer time frame on the order of 10 to 15 years and may inform the next ESA section 7 consultation and development of a new ITP

Sacramento River Winter-Run Chinook Salmon Old and Middle River Management: Bin 2

On-ramping and off-ramping OMR flow management for SR winter-run Chinook salmon is currently informed by SaMT. Sections 3.7.4.1 and 3.7.4.5.3 of the proposed action (U.S. Bureau of Reclamation 2023-2024) describe the use of SR winter-run Chinook salmon weekly and annual loss thresholds to trigger actions aimed to minimize entrainment and loss of juvenile out-migrants. It is anticipated that the criteria associated with the Winter-Run Chinook Salmon Machine Learning Model will need to be reassessed using the genetics-based run-identification loss dataset currently available (Section 3.7.4.1 in U.S. Bureau of Reclamation 2023-2024).

The development of a model explicitly predicting daily SR winter-run Chinook salmon migration timing using historical long-term monitoring data and environmental variables is necessary to reduce the uncertainty of the weekly Salmonid Distribution Table. This model needs to be made readily available as a transparent prediction tool that leverages recent biotic and abiotic data to predict current and near-future migration timing and provided to the SaMT to inform their weekly risk assessments to the WOMT. This effort should be completed and implemented no later than 2026.

Loss associated with salvage events at the SWP and CVP facilities is currently used to trigger OMR management actions, but these detections in salvage occur days or even weeks after individuals were initially entrained into the South Delta and account for only a proportion of

entrained individuals lost to the population. A new modeling framework is necessary for more effective real-time OMR management actions to be used to minimize SR winter-run Chinook salmon entrainment into the South Delta. Specifically, the modeling framework should integrate an SR winter-run Chinook salmon distribution model with PTM outcomes (potentially the individual-based ECO-PTM model developed by USGS and DWR) to estimate the proportion of the out-migrant population vulnerable to entrainment into the South Delta per day, the probability of entrainment into the South Delta given current hydrologic conditions, and the travel time to the water export facilities. Such a modeling framework should be converted into a real-time assessment tool for the SaMT to recommend OMR management actions to minimize entrainment into the South Delta well before salvage events occur.

These tools would improve the ability of the SaMT to assess and forecast SR winter-run Chinook salmon exposure to real-time risks related to Delta operations and, in concept, reduce adverse responses to exposure to water operations, thereby reducing effects to individuals.

Central Valley Spring-Run Chinook Salmon Old and Middle River Management: Bin 2

Section 3.9.2: "Spring-run OMR Management, Science, and Monitoring" of the proposed action (U.S. Bureau of Reclamation 2023-2024) describes an approach to minimize impacts of SWP and CVP operations in the South Delta on Sacramento River-origin CV spring-run Chinook salmon that relies on detection of hatchery-origin Chinook salmon (CV spring-, fall-, and late fall-run Chinook salmon) in salvage at the SWP and CVP facilities as surrogates for entrainment of natural-origin CV spring-run Chinook salmon in the Central and South Delta. While implementing the CV spring-run Chinook salmon Hatchery Surrogate measure, a parallel effort is ongoing to develop an annual CV spring-run Chinook salmon JPE (Section 3.9.2 in U.S. Bureau of Reclamation 2023-2024). Section 3.9.2 of the proposed action describes the timeline for initial program development (interim monitoring, special studies, and development of the JPE database and model) and the intention to utilize independent peer reviews (U.S. Bureau of Reclamation 2023-2024).

Development of an interim CV spring-run Chinook salmon JPE is ongoing, and independent peer reviews of the CV spring-run Chinook salmon JPE program will be considered in the near term. Additionally, the Spring-run JPE Core Team is tasked with reviewing the CV spring-run Chinook salmon Hatchery Surrogate measure (see the Special Studies section of the BA [U.S. Bureau of Reclamation 2023-2024]) in early 2025.

Refinements to the CV spring-run Chinook salmon surrogate and the CV spring-run Chinook salmon JPE program would improve the ability of the SaMT to assess and forecast CV spring-run Chinook salmon yearling and young-of-year exposure to real-time risks related to Delta operations and, in concept, reduce adverse responses to exposure to water operations, thereby reducing impacts to individuals.

Summer-Fall Habitat Action for Delta Smelt: Bins 2 and 3

This action proposes to study habitat effects on Delta smelt survival and evaluate the effectiveness of mitigation actions in improving habitat and food availability.

The action is not expected to have any consequences for SR winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, or sDPS green sturgeon.

Tidal Habitat Restoration Effectiveness for Smelt Fishes: Bins 1 and 3

Reclamation and DWR propose to carry forward habitat restoration acre targets identified from the 2008 and 2019 USFWS' biological opinions (8,000 acres) and the 2020 ITP (396.3 acres) to complete mitigation requirements for Delta smelt and longfin smelt (per the 2020 ITP). Reclamation and DWR propose to meet the total acreage requirement (8,396.3 acres) through the completion of habitat restoration projects. The projects identified in the proposed action are in different phases of completion: (1) constructed (3,584 acres), (2) in construction (3,490 acres), or (3) planned (1,662 acres). All identified restoration projects are located in the northern arc of the upper estuary and are designed to enhance food production and rearing habitat for Delta smelt and longfin smelt (per the 2020 ITP). Reclamation and DWR will complete its 8,396.3-acre restoration requirements by 2026.

Effectiveness evaluations for habitat restoration activities would not directly affect listed salmon and sturgeon, but the information could be used to improve the effectiveness of future habitat designs. There are no anticipated adverse responses for the evaluations on SR winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, or sDPS green sturgeon.

Tributary Habitat Restoration Effectiveness for Salmonid Fishes: Bins 1 and 3

The Upper Sacramento River Anadromous Fish Habitat Restoration Project Monitoring Plan and Protocols (U.S. Fish and Wildlife Service 2017b) are designed to determine the effectiveness of the Upper Sacramento River Anadromous Fish Habitat Restoration Project in meeting identified objectives and to validate the linkage between restoration actions and the biologic response to those actions.

Salmon and steelhead exposure to effectiveness evaluations are expected to improve the scientific understanding of habitat projects that influence juvenile salmon growth, rearing, and survival and could be used to improve the effectiveness of future habitat designs. There are no anticipated adverse responses associated with the evaluations.

Shasta Spring Pulse Flow Studies: Bins 2 and 3

Reclamation will release up to 150 TAF in pulse flow(s) each water year to benefit Chinook salmon in the Sacramento River watershed. In 2021, a multi-year Upper Sacramento River Spring Pulse Flow Study Plan was developed by Reclamation in coordination with CDFW, USFWS, NMFS, SWRCB, SRSCs, and the University of California, Santa Cruz. The timing, magnitude, duration, and frequency of the pulse flows will be evaluated and refined by the SRG on an annual basis and with the intent of maximizing multi-species benefits, which may include coordinating the timing of pulse flows with natural flow events and/or pulse flows in tributaries.

Hindcast evaluation of action effectiveness will include a technical review of the functional elements of the pulse flow (i.e., timing, magnitude, duration, and frequency) as well as an evaluation of criteria used to support beneficial use decisions.

Spring pulse flow studies are expected to improve the scientific understanding of managed releases that are targeted to influence juvenile salmon growth, rearing, and survival. These studies will be used to refine future pulse flows for the purpose of targeting the exposure of certain populations to flow events, improving fish response in terms of survival of salmon in the Sacramento River, and reducing exposure to certain stressors that affect survival, such as predation and elevated water temperatures.

Sacramento River Winter-Run Chinook Salmon Through Delta Survival and Salvage Thresholds: Bin 2

There is considerable uncertainty surrounding the implications of facility loss of juvenile SR winter-run Chinook salmon at CVP and SWP facilities for through-Delta survival in the Central Valley Bay-Delta. Studies will be completed to address uncertainties in the estimation of through-Delta survival. These newly generated modeling results will be used to propose and update decision support tools for juvenile Chinook salmon related to out-migration survival and entrainment risk and may change the triggers for export reductions. This work may be of interest to independent review panels. New information and its application may inform a future reinitiation of consultation and ITP amendments.

This action is a study and is not expected to have any immediate adverse or beneficial consequences for salmon or impacts to habitat. However, we expect that addressing areas of uncertainty would be used to afford more enhanced protective mechanisms for SR winter-run Chinook salmon survival. Adjusted salvage thresholds could expose SR winter-run Chinook salmon to changed hydrologic conditions, but enhanced modeling tools could result in species responses that reduce the potential for adverse effects.

Longfin Smelt Science Plan Actions: Bin 2

The Special Studies Section of the proposed action (U.S. Bureau of Reclamation 2023-2024) describes the continued implementation of the Longfin Smelt Science Program and its science plan. The science plan is a roadmap for addressing substantial gaps in our understanding of the biology and ecology of longfin smelt, which includes management activities needed to prevent further decline of the species within the San Francisco Estuary.

The action is not expected to have any consequences for SR winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, or sDPS green sturgeon.

Delta Smelt Supplementation: Bins 1 and 2

Reclamation and DWR will support a minimum production of 125,000 fish by water year 2024, a minimum of 150,000 fish by water year 2025, and a minimum of 200,000 fish by water year 2026, if feasible, that are at least 200 days post-hatch or equivalent. Through the Culture and Supplementation of Smelt Steering Committee, Reclamation, and DWR will continue to collaborate with USFWS and CDFW on the development of a program to conduct supplementation of the wild Delta smelt population with propagated fish consistent with the USFWS Supplementation Strategy (U.S. Fish and Wildlife Service 2020a).

The Supplementation Strategy currently uses the University of California, Davis Fish Conservation and Culture Laboratory but also identifies a need for additional facilities and the evaluation of new approaches to maintain these fish, support supplementation, improve transportation and release of fish, maximize genetic diversity, and minimize domestication effects. An existing Master Plan for a Delta Smelt Conservation Facility Fish Technology Center is currently being revisited and further developed to a 35-percent design-level plan (U.S. Bureau of Reclamation 2023-2024). Additional facilities would require subsequent environmental authorization for their construction and eventual operation. Reclamation and DWR will collaborate with USFWS and CDFW for the additional development of this planning effort, incorporation into the Supplementation Strategy, and the construction and operational needs of facilities capable of meeting production of 400,000–500,000 fish that are at least 200 days post-hatch by water year 2030.

The action is not expected to have any consequences for SR winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, or sDPS green sturgeon.

California Central Valley Steelhead Juvenile Production Estimate: Bin 2

Reclamation proposes to develop a CCV steelhead JPE for tributaries with CVP facilities that will focus on the annual production of out-migrating juvenile CCV steelhead. Data used in the JPE will inform the status and trends of Sacramento and San Joaquin Basin CCV steelhead and may also help inform actions that will increase CCV steelhead abundance and improve CCV steelhead survival through the Delta. The effort will also continue CCV steelhead telemetry work and the development of a CCV steelhead life cycle model.

There is a lack of detail currently available about what specific actions may be taken to develop a JPE and what kinds of adverse impacts would be expected to juveniles associated with monitoring and studies. However, the information is expected to be used to develop refined salvage thresholds that are based on biological metrics such as population size, instead of historical salvage. There may be certain actions that will expose CCV steelhead to capture, handling, and tagging, with some level of expected sublethal or lethal effects. These detailed effects will be evaluated and authorized in the future when specific study proposals are formulated for implementation. Ultimately, the use of population-based salvage thresholds would reduce the potential for adverse impacts to CCV steelhead.

Alternative Salmonid Loss Estimation Pilot Study: Bin 2

Within the first year of the effective date of the ROD or ITP, DWR, in collaboration with Reclamation, will convene the Alternative Loss Equation Technical Team (ALE-TT) and conduct a knowledge transfer and methods workshop for the ALE-22 tool and prepare a draft ALPS-IP for ALE-TT review. Within the second year of the effective date of the ROD or ITP, DWR will submit the final draft ALPS-IP for both the ALE-TT and AMSC review. DWR will finalize the ALPS-IP once approved by the AMSC and establish priorities for implementation (e.g., loss parameter studies) using structured decision-making within the ALE-TT. The ALE-TT may utilize an independent science panel review to further enhance the structured decision-making prioritization process. In the third year of the effective date of the ROD or ITP, DWR will submit prioritized ALPS-IP recommendations, informed by the ALE-TT structured

decision-making process, to the AMSC for approval. The permittee shall then update the loss equation with refinement to the loss equation components as approved by CDFW.

The goal of this pilot study is to provide more accurate estimates of loss and loss parameters at the SWP and CVP export facilities while understanding the utility of the new alternative method relative to the existing method. If the pilot efforts yield applicable outcomes, we would expect to improve real-time assessments of loss, which could lead to improved use of thresholds and triggers and improved protection of salmon and steelhead at the salvage facilities.

Shasta Cold Water Pool Management: Bin 2

Reclamation will operate Shasta Reservoir to build a cold-water pool and use the Temperature Control Device on Shasta Dam to blend water from different reservoir strata to protect downstream SR winter-run Chinook salmon returning adults and incubating eggs from temperature stressors. An annual operation of the Shasta Temperature Control Device and the development of the TMP will be developed as part of real-time operations. Shasta Reservoir cold water pool management will rely on an objectives-based management framework adapted from the multi-year drought sequence experienced in Victoria, Australia (Mount et al. 2016) that considers the available hydrology to "Protect," "Maintain," "Recover," and "Enhance" protected species, habitats, and water deliveries. An initial set of objectives and metrics will be further refined according to an increased understanding of species needs, interannual hydrologic conditions (e.g., drought), and operational limitations.

Hindcast evaluation of action effectiveness includes a review of the objectives and metrics used to guide annual temperature planning. Objective-based storage targets and TDM will be considered with regard to their ability to support species viability and water delivery performance.

This action is effectively integrated with the implementation of the Shasta Framework and will be used to refine and improve the framework over time, including modifications to Shasta Framework objectives to improve SR winter-run Chinook salmon survival and viability. This action assesses fish exposure and response to previous years' monitoring and modeling data and is used to improve management and reduce potential impacts to SR winter-run Chinook salmon.

Georgiana Slough Migratory Barrier Effectiveness for Salmonid Fishes: Bin 2

The DWR, in coordination with Reclamation, will continue to seasonally install and operate a salmonid migratory barrier at Georgiana Slough each year to reduce entrainment into the Central and South Delta of emigrating juvenile salmonids. Operation of the salmonid migratory barrier should improve the seasonally averaged through-Delta survival probability to Chipps Island compared with survival probability if the salmonid barrier were not in operation. Barrier operations and monitoring details are defined in the GSSMB Operations and Monitoring Plans developed by the GSSMB Coordination Group. To further maximize seasonal survival benefits to migrating salmonids, DWR and Reclamation will continue leading the GSSMB Coordination Group with the membership of DWR, Reclamation, CDFW, USFWS, NMFS, and State/Federal Water Contractors representatives. Reclamation and DWR, working with the GSSMB Coordination Group, will provide at least a triennial report and review and update, as necessary, the GSSMB Operations and Monitoring Plans.

NMFS expects that the report of GSSMB operations and monitoring will be used to inform necessary changes/updates to the Operations and Monitoring Plans, and that these plans will be applied to reduce SR winter-run Chinook salmon exposure to entrainment into the Central and South Delta and reduce impacts to out-migrating salmon and steelhead.

Spring Outflow: Bin 3

During implementation, supplemental spring flows will be managed by real-time operation groups to determine the source, schedule, and amount of water to ensure consistency with proposed flow levels.

A Voluntary Agreement Science Committee will support the adaptive management of spring outflows by providing the multi-year, synthetic evaluation developed for the VA Program to the AMSC to inform future major reinitiation of consultation and ITP amendments.

SR winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon will not be exposed to any additional stressors or consequences as a result of this action. Therefore, we do not anticipate any beneficial or adverse responses and no additional adverse impacts to species or critical habitat.

Clear Creek: Bin 2

A draft proposal from Reclamation for long-term Clear Creek/Whiskeytown Reservoir operations includes a novel approach to exerting desirable intra-annual flow variability. A draft new flow regime would implement variable flows over the course of a year that would range from flow releases as low as 100 cfs in late summer, adapting flow needs during CV spring-run Chinook salmon spawning/the onset of fall-run Chinook salmon spawning in September/October, and (ultimately) slowly ramping up to 300 cfs in the winter when fry could benefit from seasonally inundated surfaces, then ramping back down to 100 cfs the following summer to start again. This flow variability will create a more natural seasonally variable hydrograph and is expected to provide an opportunity for gravel augmentation or other restoration to target surface elevations and channel form for seasonal inundation to benefit salmon rearing.

There are expected benefits and potential consequences from these changes. Continuation of existing and some proposed monitoring efforts including, but not limited to, USFWS Red Bluff Office-maintained temperature loggers, Potential Spawning Area Mapping, Spawn Area Mapping, rotary screw trapping, spawning surveys, snorkel surveys, video weir, redd mapping, and proposed habitat monitoring will be important for evaluation of these management actions.

Central Valley Spring-Run Chinook Salmon Juvenile Production Estimate and Life Cycle Model: No Bin has been assigned

Reclamation and DWR will support the continued development of a CV spring-run Chinook salmon JPE framework for CVP and SWP tributaries and the Delta and propose a framework for implementation, including an approach for modeling a CV spring-run Chinook salmon JPE and the monitoring program to support that approach. The CV spring-run Chinook salmon JPE framework will incorporate independent review and will be the basis for consideration of

updated entrainment minimization measures, including updating hatchery surrogate measures. The process to develop the framework will continue the ongoing effort to develop a CV spring-run Chinook salmon JPE initiated in 2020 and outlined in the Spring-run Chinook Salmon JPE Science Plan (Department of Water Resources 2020), the Interim Monitoring Plan for the Spring-run Chinook Salmon JPE Science Program (Allison et al. 2021), the Spring-run Chinook Salmon JPE Run Identification Research and Initial Monitoring Plan (Bedwell et al. 2021), the Spring-run Chinook Salmon JPE Data Management Strategy (Harvey et al. 2022), and the Spring-run Chinook Salmon JPE Decision Charter (Horndeski and Harvey 2022). These plans describe the decision processes, research, monitoring, and data management infrastructure that will be needed to meet the goal of developing a CV spring-run Chinook salmon JPE ready for implementation in 2025, including guidance by an interagency Core Team using structured decision-making principles, rapid and coordinated reporting of new data onto a publicly accessible repository, routine and rapid genetic testing, and additions to existing and/or new monitoring programs at Delta entry and in representative spring-run streams: Clear Creek, Battle Creek, Mill Creek, Deer Creek, Butte Creek, Yuba River, and Feather River.

A CV spring-run Chinook salmon JPE will ultimately be used to develop refined salvage thresholds that are based on biological metrics, such as population size, instead of historical salvage. There may be certain actions that will expose CV spring-run Chinook salmon to capture, handling, and tagging, with some level of expected sublethal or lethal effects. These effects will be evaluated and authorized in the future when specific study proposals are formulated for implementation. Ultimately, the use of population-based salvage thresholds would reduce potential impacts to CV spring-run Chinook salmon through tools and mechanisms that provide for more precise protections of Core 1 and Core 2 CV spring-run Chinook salmon populations.

Sacramento River Winter-Run Chinook Salmon Life Stage Studies: No Bin has been assigned

SR winter-run Chinook salmon are exposed to a variety of stressors throughout their life cycle that impair their survival, reproduction, and the ability of the population to rebound from periods of low abundance. Survival during early life stages—spawning success, egg incubation, emergence, and juvenile rearing and migration—is affected by various environmental factors.

Understanding the relative contribution of different stressors, particularly those that we can manage through water operations and other actions, will improve our ability to manage water and improve SR winter-run Chinook salmon early life stage survival. There may be certain actions that will expose CV spring-run Chinook salmon to capture, handling, and tagging, with some level of expected sublethal or lethal effects. These effects will be evaluated and authorized in the future when specific study proposals are formulated for implementation. Ultimately, the results of future life stage studies would reduce the risk to SR winter-run Chinook salmon that are exposed to project operations.

Delta Route Selection and Survival: No Bin has been assigned

These studies involve an acoustic receiver network and associated real-time and retrospective modeling of the data. The objectives are to provide real-time estimates of reach-specific survival and route entrainment for juvenile salmonids in the Sacramento River and Delta. We do not anticipate any adverse impacts from deploying the network. The use of improved tools in real-

time operations will be used to minimize exposure, adverse response, and adverse effects to salmon and steelhead from Delta operations.

Longfin Smelt Science Plan: No Bin has been assigned

NMFS does not expect any adverse exposure or response to salmon, steelhead, or sDPS green sturgeon from Longfin Smelt Science.

Longfin Smelt Science and Monitoring Initiatives: No Bin has been assigned

NMFS does not expect any adverse exposure or response to salmon, steelhead, or sDPS green sturgeon from Longfin Smelt Science.

Management of Sacramento River Winter-Run Chinook Salmon Spawning Location and Timing: No Bin has been assigned

Reclamation will study how flow and temperatures can be used to manage SR winter-run Chinook salmon spawning on the Sacramento River. Reclamation will support the applicable costs and implement the results of the studies, contingent on available appropriations, to improve future management, as applicable. This action does not specify the funding level for this project, only the commitment to fund as appropriations are available. The goal of this management action is to ensure a resilient portfolio of life history strategies by supporting a diversity of spawn timings and locations in the population.

This would essentially be a paper study that would not expose any salmon to adverse conditions that could result in adverse impacts to individuals. If the study yields new approaches for managing the onset of SR winter-run Chinook salmon spawning conditions in a manner that improves survival and supports diverse life history conditions, then they will be re-evaluated through the AMP, and the specific responses will be more closely evaluated.

8. CUMULATIVE EFFECTS

"Cumulative effects" are those effects of future state or private activities, not involving federal activities, that are reasonably certain to occur within the action area of the federal action subject to consultation (50 CFR 402.02). Future federal actions unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

Some continuing non-federal activities are reasonably certain to contribute to climate effects within the action area. However, it is difficult, if not impossible, to distinguish between the action area's future environmental conditions caused by global climate change that are properly part of the environmental baseline versus cumulative effects. Therefore, all relevant future climate-related environmental conditions in the action area are described in the environmental baseline.

8.1. Unscreened Water Diversions

Water diversions for irrigated agriculture, municipal and industrial use, and managed wetlands are found throughout the California Central Valley. Thousands of small and medium-size water

diversions exist along the Sacramento River, San Joaquin River, their tributaries, and the Delta, and many of them remain unscreened. Depending on the size, location, and season of operation, these unscreened diversions entrain and kill many life stages of aquatic species, including juvenile listed anadromous species (Mussen et al. 2013, Mussen et al. 2014b). In 1997, 98.5 percent of the 3,356 diversions included in a Central Valley database were either unscreened or screened insufficiently to prevent fish entrainment (Herren and Kawasaki 2001). More recent data show that over 95 percent of the now over 3,700 water diversions on the Sacramento and San Joaquin rivers, their tributaries, and the Delta, remain unscreened (CalFish 2019). The impacts from unscreened water diversions have improved due to the anadromous fish screen program, part of CVPIA, as well as DWR's fish screening program (Meier 2013). While private irrigation diversions in the Delta are mostly unscreened, the total amount of water diverted onto Delta farms has remained stable for decades (Culberson et al. 2008). A study of a dozen unscreened diversions in the Sacramento River, all relatively deep in the channel, reported low entrainment for listed salmonids and steelhead (Vogel 2013).

8.2. Agricultural Practices

Agricultural practices may negatively affect riparian and wetland habitats through upland modifications that lead to increased siltation or reductions in water flow in stream channels flowing into the action area, including the Sacramento River, Stanislaus River, San Joaquin River, and Delta. Grazing activities from dairy and cattle operations can degrade or reduce suitable critical habitat for listed fish species by increasing erosion and sedimentation. These practices introduce nitrogen, ammonia, and other nutrients into the watershed, which then flow into receiving waters (Lehman et al. 2014). Ammonia introduction from agricultural activities can be additive with much larger sources, such as wastewater treatment discharges.

Salmonids and sturgeon exposure to contaminants is inherent in the Delta, ranging in the degree of effects. Stormwater and irrigation discharges related to agricultural activities contain numerous pesticides, herbicides, and other contaminants that may disrupt various physiological mechanisms and negatively affect reproductive success and survival rates of listed anadromous fish (Dubrovsky et al. 1998, Scott and Sloman 2004, Whitehead et al. 2004, Scholz et al. 2012). Agricultural operations outside the action area can result in discharges that flow into the action area and contribute to cumulative effects of contaminant exposure. The State of California issues waste discharge requirements to dischargers, including irrigators, dairy operations, and cattle operations, that require the implementation of best management practices designed to protect surface water quality, with benefits for listed fish species. Agricultural operations have monitoring and reporting requirements associated with those waste discharge requirements that ensure compliance with best management practices.

8.3. Wastewater Treatment Plants

Two wastewater treatment plants (one located on the Sacramento River near Freeport and the other on the San Joaquin River near Stockton) have received special attention because of their discharge of ammonia. The EPA published revised national recommended ambient water quality criteria for the protection of aquatic life from the toxic effects of ammonia in 2013. However, few studies have been conducted to assess the effects of ammonia on Chinook salmon, steelhead, or sturgeon. Studies of ammonia effects on various fish species have shown numerous effects, including membrane transport deficiencies, increases in energy consumption, immune system

impairments, gill lamellae fusions deformities, liver hydropic degenerations, glomerular nephritis, and nervous and muscular system effects leading to mortality (Eddy 2005, Connon et al. 2011).

(Werner et al. 2008, Werner et al. 2009, Werner et al. 2010) analyzed the acute effects of Sacramento Regional Wastewater Treatment Plant effluent on Delta smelt, rainbow trout, and fathead minnow. The studies found that at ammonia/um concentrations reported downstream of the discharge, on average below 1 milligram per liter ammonia/um, lethal toxicity effects are not expected. In general, this lack of toxicity was attributed to the fact that the lethal concentration at which 50 percent of individuals exposed die (i.e., LC50 values) was much higher than ammonia concentrations reported in environmental sampling. However, the studies did not assess sublethal toxicity. Sublethal ammonia toxicity at concentrations similar to what had been reported downstream of Sacramento Regional Wastewater Treatment Plant (less than 1 milligrams per liter) has been demonstrated in fish. In a study of coho salmon and rainbow trout exposed to ammonia, (Wicks et al. 2002) showed a decrease in swimming performance due to metabolic challenges and depolarization of white muscle, and found that ammonia was significantly more toxic for active fish. Furthermore, fish exposed to sublethal concentrations of ammonia/um have exhibited increased respiratory activity and heart rate, loss of equilibrium, and hyper-excitability (Eddy 2005). None of these studies assessed the chronic effects of ammonia/um exposure that may occur at lower concentrations on the behavior, reproduction, or long-term survival of ESA-listed or surrogate species. However, (Werner et al. 2009)concluded that "ammonia/um concentrations detected in the Sacramento River below the Sacramento Regional Wastewater Treatment Plant are of concern with respect to chronic toxicity to Delta smelt and other sensitive species."

The Sacramento Regional Wastewater Treatment Plant, in order to comply with Order no. R5-2013-0124, began implementing compliance measures to reduce ammonia discharges. Construction of treatment facilities for three major projects required for ammonia and nitrate reduction was initiated in March 2015 (Sacramento Regional County Sanitation District 2015). The order was modified in October 2013 by the Central Valley Regional Water Quality Control Board to impose new effluent limitations, requiring effluent limits for ammonia of 2.0 milligrams per liter per day from April to October, and 3.3 milligrams per liter per day from November to March (Central Valley Regional Water Quality Control Board 2016). However, the board concluded that compliance with these effluent limitations was not feasible, and put the plant in non-compliance with the ammonia final effluent limitations. In September 2020, the Sacramento Regional Wastewater Treatment Plant requested a Time Schedule Order to extend the compliance schedule to allow additional time to complete upgrades to the Facility. Time Schedule Order R5-2020-0904 was issued on December 4, 2020, which provided a schedule to achieve compliance with final effluent limitations for ammonia by June 1, 2022 (Central Valley Regional Water Quality Control Board 2019, State of California Department of Finance 2023). As of spring 2023, the Sacramento Regional Wastewater Treatment Plant completed extensive upgrades, and the treatment process now removes 99 percent of ammonia.

8.4. Increased Urbanization

California's current population is approximately 39.1 million people. California's population declined during the COVID-19 era, with the largest decrease during the first year (-0.75 percent in fiscal year 2020–2021). Despite the effect of COVID-19, the California Department of

Finance projects that California's population will increase to 40.2 million in 2044, and then decrease to 39.6 million by 2060 (State of California Department of Finance 2023). The increase between now and 2044 will likely be accompanied by increases in urbanization and housing developments. The Delta, East Bay, and Sacramento regions include portions of Alameda, Sacramento, San Joaquin, Solano, Stanislaus, Yolo, and Yuba counties. Population growth rate was highest in Yuba County (0.76 percent, State of California Department of Finance 2023).

Increases in urbanization and housing developments can impact habitat by altering watershed characteristics and changing both water use and stormwater runoff patterns. Increased growth will place additional burdens on resource allocations, including natural gas, electricity, and water, as well as on infrastructure such as wastewater sanitation plants, roads, highways, and public utilities. Some of these actions, particularly those situated away from waterbodies, will not require federal permits and thus will not undergo review through ESA section 7 consultations.

Negative effects on listed fish species and their critical habitats may result from urbanization-induced point and non-point source chemical contaminant discharges within the action area. These contaminants, which include, but are not limited to, ammonia and free ammonium ion, numerous pesticides and herbicides, and oil and gasoline product discharges, may disrupt various physiological mechanisms and may negatively affect reproductive success and survival rates of listed anadromous fish (Dubrovsky et al. 1998, Scott and Sloman 2004, Whitehead et al. 2004, Scholz et al. 2012).

8.5. Recreational Activities in the Region

Recreational boating is expected to increase in volume and frequency as urbanization increases. Boating activities typically result in increased wave action and propeller wash in waterways. This may potentially degrade riparian and wetland habitats by eroding channel banks and mid-channel islands, thereby causing an increase in siltation and turbidity. Wakes and propeller wash also churn up benthic sediments, thereby potentially resuspending contaminated sediments and degrading areas of submerged vegetation, which, in turn, would reduce habitat quality for the invertebrate forage base required for listed fish species. Increased recreational boat operation is anticipated to result in more contamination from the operation of gasoline and diesel-powered engines on watercraft entering the associated water bodies.

8.6. Changes in Non-Central Valley Project or State Water Project Diversions

Changes in location, volume, timing, and delivery method for non-CVP or SWP diversions may be fully or partially implemented without requiring ESA section 7 consultations. While non-CVP or SWP diversions are reasonably certain to occur, the details of implementation are not certain, and changes may be expected to occur due to:

- Implementation of the California Sustainable Groundwater Management Act that requires development and implementation of Groundwater Sustainability Plans
- Implementation of the California Senate Bill X7-7 provisions, which require the State to achieve a 20-percent reduction in urban per capita water use by December 31, 2020
- Implementation of the California 2009 Delta Reform Act (implementation of portions of the Delta Reform Act also is part of the California Water Action Plan)

- Implementation of the California Water Action Plan released by Governor Jerry Brown in January 2014, specifically for provisions of the plan that would not necessarily require separate environmental documentation and consultation for related federal actions

Reduced reliance on groundwater under the California Sustainable Groundwater Management Act could result in increased surface water diversions in some cases and associated impacts on listed species. Reduction of urban water use would be expected to have beneficial effects to listed species by reducing diversions.

NMFS does not currently have information on the specific impacts of these programs to listed fish species or critical habitat; thus, NMFS cannot determine the specific impacts of these programs. NMFS expects that habitat restoration activities under the California Water Action Plan would have short-term effects (sedimentation, turbidity, acoustic noise, temporary habitat disturbance) similar to the effects discussed in this opinion for similar habitat restoration activities. In general, NMFS expects that the implementation of these programs will improve habitat conditions for listed fish into the future through the increased availability of instream flows and habitat restoration.

8.7. Activities Within the Nearshore Pacific Ocean

Future tribal, state, and local government actions could occur through legislation, administrative rules, policy initiatives, or fishing permits. Activities are primarily those conducted under state and tribal management. These actions may include changes in ocean policy, types of fishing activities, resource extraction, or designation of marine protected areas. The magnitude of impacts associated with these types of activities on listed fish species or their habitat is uncertain. Although state, tribal, and local governments have developed plans and initiatives to benefit marine fish species, ESA-listed salmonids, sDPS green sturgeon, and SRKWs, they must be applied and sustained in a comprehensive way before NMFS can consider them "reasonably certain to occur" in its analysis of cumulative effects. Government actions are subject to policy, legislative, and fiscal uncertainties. These realities, added to the geographic scope, which encompasses several government entities exercising various authorities, and the changing economies of the region, make analysis of cumulative effects speculative.

Private activities are primarily associated with commercial and sport fisheries, construction, and marine pollution. These potential factors are ongoing and expected to continue in the future, and the level of their impact is uncertain. For these reasons, it is not possible to predict beyond what is included in the subsections pertaining to cumulative effects above, whether future non-federal actions will lead to an increase or decrease in prey available to SRKWs, or have other effects on their survival and recovery.

Therefore, the activities in this section are being excluded as they are too speculative to analyze and do not rise to the level of cumulative effects.

8.8. Other Ongoing Activities

Other future, non-federal actions within the action area include: the dumping of domestic and industrial waste that decreases water quality; oil and gas development and production that may affect aquatic habitat and may introduce pollutants into the water; infrastructure including roads, state and local dredging projects; and state or local levee maintenance that may also destroy or negatively affect habitat and interfere with natural, long-term habitat-maintaining processes.

Power plant cooling system operations can also affect aquatic habitat. A statewide policy on the use of coastal and estuarine water for power plant cooling, also called the once-through cooling policy, adopted by the SWRCB in 2010 under Resolution No. 2010-0020 and amended in 2017 under Resolution No. 2017-0047, requires existing cooling water intake structures to reflect the best technology available for minimizing adverse environmental impacts (State Water Resources Control Board 2010, 2017a). Since this policy was adopted, several power-generating units have been retired or repowered (Statewide Advisory Committee 2022). For example, Contra Costa Power Plant, which was owned and operated by NRG Delta, LLC, was retired in 2013 and replaced with the new natural gas power plant, Marsh Landing Generating Station. Additionally, the Pittsburg Generating Station ceased operations in December of 2016 (Statewide Advisory Committee 2022).

The once-through cooling system intake process can cause the impingement and entrainment of estuarine and marine animals, kill organisms from all levels of the food chain, and disrupt the normal processes of the ecosystem. Additionally, the plant can discharge heated water that can reach temperatures as high as 100°F into the action area. This sudden influx of hot water can negatively affect the ecosystem and the animals living in it (San Francisco Baykeeper 2010). The once-through cooling policy includes provisions that mitigate impingement and entrainment impacts resulting from cooling water intakes, decreasing the occurrence of these events for ESA-listed fish at all life stages (Statewide Advisory Committee 2019). However, it does not address problems associated with elevated temperatures in discharged water.

This consultation assumed effects in the future would be similar to those in the past and, therefore, are reflected in the anticipated trends described in the status of the species and environmental baseline sections.

9. INTEGRATION AND SYNTHESIS

The Integration and Synthesis section is the final step in our assessment of the risk that the proposed action poses to species and critical habitat. In this section, we add the effects of the action (Section 7) to the environmental baseline (Section 6) and the cumulative effects (Section 8), taking into account the status of the species and critical habitat (Section 4), to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) appreciably diminishes the value of designated or proposed critical habitat for the conservation of the species. In this opinion, NMFS uses the VSP parameters of abundance, productivity, spatial structure, and diversity to represent the species' reproduction, numbers, or distribution for this assessment.

Numerous models and modeling scenarios (U.S. Bureau of Reclamation 2023-2024) were considered throughout this opinion which have been used to inform the effects to the species and critical habitat in the Environmental Baseline and Effects Analyses sections of this opinion. The modeling scenarios are used to analyze the effects of the proposed action and also inform the context of how the new proposed action performs during challenging circumstances, such as drought, and management actions such as pulse flows, water temperature management plans, OMR management actions, and changes to Delta spring outflow. In the Effects Analysis sections of the opinion, separating the obligated release scenarios from the discretionary effects of the

proposed action helped us isolate the effects of the action from other requirements. Likewise, analyzing the difference between the effects of the proposed action from the effects of the NAA models helped us understand the effects of the action as they are added to an environmental baseline that includes the ongoing effects of current operations. From this perspective, specific models serve as useful tools for accurately predicting effects to individuals but are unable to capture the precise conditions that are expected in real time. During real-time operations, additional modeling is often used to inform seasonal decision-making and to ensure that real-time effects are within the range of effects considered in this opinion. While this opinion relies on the modeling outputs to assess a change in fitness for an individual of a species, no modeling captures the totality of project effects. Rather, the conclusions in this opinion are informed by the status of the species and the aggregate effects of the environmental baseline, and the analyzed effects of the proposed action and cumulative effects, considered through the lens of VSP parameters. We use life cycle models for SR winter-run Chinook salmon as another line of evidence to inform our analysis. As discussed in the Life Cycle Modeling Section of this opinion (Section 7.7), life cycle models should not be used to provide absolute measures of abundance or productivity, but results are informative when viewed in relation to other operational scenarios and in this section, we compared the results to current operations. The strength of the life cycle modeling remains in its capability to integrate effects across the various life stages. It is used to inform how a population or species may respond to changes to the proposed action that are different from current operations.

The proposed action is expected to adversely affect several life history stages of SR winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, sDPS green sturgeon, and SRKW. As proposed action effects can differ for each species, they will be discussed separately in the following sections.

The following sections are organized by species and designated critical habitat. The aggregate effects in species and critical habitat are discussed separately. Each section will provide a summary of the status of the species and their designated critical habitat, a summary of the effects of the proposed action on listed species and critical habitat, a summary of risk to the species and critical habitat, and a discussion of climate change considerations.

The aggregate of the jeopardy and adverse modification analyses also includes an evaluation of proposed framework programmatic activities to assess how they would function within the context of Reclamation and DWR's operation of the CVP and SWP, including how they would influence the nature of effects to listed species and their critical habitat. The evaluation of framework programmatic actions considers if the framework action descriptions include conservation measures, guiding principles, best management activities and/or adaptive management provisions that would avoid, minimize or mitigate for the consequences of future project activities on listed species and their designated critical habitat. Under a framework programmatic approach, as specific projects are developed in the future, they are subject to project-specific stepped-down, or tiered, consultations. Once framework-level action components are further developed and provide sufficient detail to analyze effects on species and critical habitat, they will require additional ESA section 7 consultation before implementation. Those subsequent consultations will include a jeopardy and adverse modification analysis to determine if these future actions would appreciably reduce the likelihood of both the survival and

recovery of a listed species or appreciably diminish the value of critical habitat for the conservation of the species. These consultations would also include an incidental take statement.

Table 168 captures the relative presence of populations throughout the CVP and SWP divisions that are part of this consultation.

Table 168. Relative presence of Core populations within Central Valley Project and State Water Project divisions that are subject to this consultation.

Division or River System	Diversity Group	Species Present	Recovery Plan Classification	Other populations in diversity group or ESU/DPS
Sacramento River	Basalt and Porous Lava	Sacramento River winter-run Chinook salmon	Core 1	The only Core 1 population in the diversity group and the ESU. Battle Creek and the McCloud River are primary reintroduction watersheds for recovery purposes. Non-natal juvenile rearing expected in other tributaries.
Sacramento River	Basalt and Porous Lava	Central Valley spring-run Chinook salmon	Core 2	Numerous other Core 1-3 populations across the diversity group and the ESU. The McCloud River is a primary reintroduction watershed for recovery purposes. Non-natal juvenile rearing expected in other tributaries.
Sacramento River	Basalt and Porous Lava	California Central Valley steelhead	Core 2	Numerous other Core 1-3 populations across the diversity group and the DPS. The McCloud River is a primary reintroduction watershed in this diversity group. Non-natal juvenile rearing expected in other tributaries.
Sacramento River	Basalt and Porous Lava	Southern Distinct Population Segment of green sturgeon	One extant independent population in the Sacramento River	Spawning documented in the Feather and Yuba rivers

Division or River System	Diversity Group	Species Present	Recovery Plan Classification	Other populations in diversity group or ESU/DPS
Clear Creek	Northwestern California	Central Valley spring-run Chinook salmon	Core 1	Only Core 1 population in the diversity group. Numerous other populations across the diversity group and the evolutionarily significant unit (ESU). There are no primary reintroduction watersheds in this diversity group. Non-natal juvenile rearing expected in other tributaries.
Clear Creek	Northwestern California	California Central Valley steelhead	Core 1	Only Core 1 population in the diversity group. Numerous other populations across the diversity group and the distinct population segment (DPS). There are no primary reintroduction watersheds in this diversity group. Non-natal juvenile rearing expected in other tributaries.
American River	Northern Sierra Nevada	California Central Valley steelhead	Core 2	Numerous other Core 1-3 populations across the diversity group and the DPS. This diversity group includes the North and Middle and South Yuba rivers as primary reintroduction watersheds. Non-natal juvenile rearing expected in other tributaries.
Eastside (Stanislaus River and San Joaquin River)	Southern Sierra Nevada	California Central Valley steelhead	Core 2	A few other Core 1-3 populations across the diversity group and the DPS. There are no primary reintroduction watersheds in this diversity group. Non-natal juvenile rearing expected in other tributaries.

Division or River System	Diversity Group	Species Present	Recovery Plan Classification	Other populations in diversity group or ESU/DPS
Eastside (Stanislaus River and San Joaquin River)	Southern Sierra Nevada	Central Valley spring-run Chinook salmon	N/A - occasionally present	No Core population in this diversity group but the Stanislaus River upstream from New Melones is a candidate area for reintroduction to historic habitat. The San Joaquin River, downstream from Friant Dam, is a primary reintroduction watershed in this diversity group. Non-natal juvenile rearing expected in other tributaries.
Eastside (Stanislaus River and San Joaquin River)	Southern Sierra Nevada	Southern Distinct Population Segment of green sturgeon	Occasionally present - no known reproduction	No priority watersheds have been identified for the San Joaquin Basin
Delta		Sacramento River winter-run Chinook salmon	Sacramento River and Livingston Stone National Fish Hatchery populations present during out-migration	The Sacramento River and Livingston Stone National Fish Hatchery populations migrate through this reach of the system.
Delta		Central Valley spring-run Chinook salmon	Multiple populations from the Sacramento and San Joaquin Basins	All populations of Central Valley spring-run Chinook salmon migrate through this reach of the system.
Delta		California Central Valley steelhead	Multiple populations from the Sacramento and San Joaquin Basins	All populations of California Central Valley steelhead migrate through this reach of the system.
Delta		Southern Distinct Population Segment of green sturgeon	Populations from the Sacramento River Basin	All populations of green sturgeon migrate through this reach of the system.

9.1. Sacramento River Winter-Run Chinook Salmon

9.1.1. Summary of the Environmental Baseline, Cumulative Effects, and Status of the Species

The single remaining extant population of SR winter-run Chinook salmon in the ESU is currently at a high risk of extinction due to the presence of only one population with a high level of hatchery influence (National Marine Fisheries Service 2023d). The ESU also continues to face threats from disease; predation; habitat loss, alteration, and degradation; and is particularly susceptible to climate change and drought (National Marine Fisheries Service 2024a). The existing population spawns in the Sacramento River immediately downstream from Shasta and Keswick reservoirs, and recent droughts in 2014 to 2016 and again in 2020 and 2021 affected early life stage survival that affected adult abundance. The status of SR winter-run Chinook salmon is described in detail in the Status of the Species section of the opinion; in the Environmental Baseline section, where the status is discussed in terms of the past and present impacts of all federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed federal projects in the action area that have already undergone formal or early ESA section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process; and in the Cumulative Effects section, that discusses the effects of future state or private activities, not involving federal activities, that are reasonably certain to occur within the action area of the federal action subject to consultation.

In this opinion, the effects of past CVP and SWP operations and existing structures are also part of the environmental baseline. Effects of those actions have been analyzed through past consultation and contributed to the current condition of the species and critical habitat in the action area. Sacramento River winter-run Chinook salmon are exposed to numerous cumulative effects such as unscreened water diversions, agricultural practices that impact water quality and riparian habitat, water contamination from municipal and agricultural sources, effects of urbanization, recreational and commercial fisheries, and other activities.

CDFW issued a CESA ITP to DWR for the LTO of the SWP in the Delta in November 2024 (California Department of Fish and Wildlife 2024c). Most of the actions covered in the CESA ITP are also covered in this opinion because DWR is an applicant in the consultation. One action that is not part of Reclamation's proposed action is the GSSMB. Operation of the GSSMB is expected to provide a higher probability of survival for emigrating juvenile salmonids that encounter the Sacramento River-Georgiana Slough junction and reduce entrainment of emigrating juvenile salmonids into the Central and South Delta and at the state and federal export facilities. The reduced routing effects of this action were not analyzed in the modeling for Reclamation's proposed action.

Abundance and productivity have shown modest improvement in the most recent years, adult escapement in 2024 was low and the full effects of the 2020–2022 drought have yet to be realized due to the 3-year life cycle of most SR winter-run Chinook salmon. Meanwhile, the spatial structure of the ESU remains limited to the single population found in the mainstem Sacramento River, and the genetic and life history diversity of the ESU may have been negatively affected by elevated water temperatures, reduced early life stage survival, and the increased hatchery production implemented to address drought conditions. The ESU also continues to face threats from disease, predation, and habitat loss, alteration, and degradation,

and is particularly susceptible to climate change and drought (National Marine Fisheries Service 2024a).

The 2023 Viability Assessment for Pacific Salmon and Steelhead Listed Under the Endangered Species Act: Southwest (National Marine Fisheries Service 2023d) concluded that the LSNFH improved the ESU demographically and genetically through increasing abundance, especially during periods of extremely poor in-river survival, but that the long-term impacts on relying on hatchery fish pose a concern to the long-term viability of the population and the ESU. The lack of population redundancy in the SR winter-run Chinook salmon ESU is the primary factor contributing to its high extinction rate, and viability will ultimately be improved by re-establishing SR winter-run Chinook salmon in historic habitats. Efforts to reintroduce fish to Battle Creek have been ongoing since 2014, when the Battle Creek SR winter-run Chinook salmon jump-start project began; evidence of successful spawning has been observed since 2020. Reintroduction efforts on the McCloud River, upstream from Shasta Reservoir, have also been ongoing since 2022 and recently concluded a third year of egg transfers, juvenile survival studies, and equipment testing.

9.1.2. Summary of the Proposed Action Effects to the Species

Sacramento River winter-run Chinook salmon are primarily exposed to project-related effects in the mainstem Sacramento River, from the vicinity of Keswick Dam downstream through the Delta. The proposed action also includes a broad portfolio of elements that are specifically developed and implemented to protect SR winter-run Chinook salmon with actions informed by comprehensive monitoring programs and science-based decision support models. The portfolio of actions is implemented and managed by Reclamation but strategically planned through interagency collaborative planning processes across multiple technical teams. The collaborative decision-making to protect SR winter-run Chinook salmon is reinforced through structured governance that allows for quick elevation and resolution when there are areas of technical or scientific disagreements.

Along the Sacramento River, SR winter-run Chinook salmon exposure to project-related water temperature effects is mostly concentrated in the area from Keswick Dam downstream several miles to the vicinity of the Clear Creek gauge. Temperature management plans and flow scheduling actions are developed by technical and policy teams and used to manage water temperature and flow conditions for spawning and egg incubation. The planning process is structured around the hydrologic water year and effectively cycles from October 1 through September 31.

Moving further downstream in the Sacramento River, flow impacts from Shasta operations begin to blend with other downstream tributaries that influence instream flow and growth and survival conditions for out-migrating juveniles. Instream flow conditions for out-migrating juveniles are influenced by natural hydrology and Reclamation's actions that build reservoir storage at Shasta through the winter, along with water allocation deliveries that occur through the spring and summer. Baseflows, ramping rates, and pulse flows are used to support the out-migration of juveniles through the Sacramento River.

Entering the Delta, upstream reservoir operations paired with export operations influence through-Delta juvenile rearing and survival conditions, routing, and entrainment into the central and south Delta. Numerous approaches are applied in the Delta to minimize the exposure of

juvenile SR winter-run Chinook salmon to operations of the CVP and SWP, including seasonal operational constraints applied to the Delta Cross Channel, annual and weekly entrainment response actions, and the use of technical and policy teams to coordinate on real-time decision making. Adaptive management is an important part of operating such a large and complicated system. It is integrated into all aspects of the operational framework of the CVP and SWP in a way that builds on the best available science and emerging science to inform future actions.

The effects analysis identified several proposed action components with stressors that have medium to high levels of severity, resulting in a medium to high magnitude effect for SR winter-run Chinook salmon. Major effects to SR winter-run Chinook salmon from the proposed action are associated with Water Temperature Management under the Shasta Framework, Fall and Winter Baseflows for Shasta Refill and Redd Maintenance, Sacramento River Pulse Flows, Delta Cross Channel Gate Operations, OMR Management and Entrainment, and Spring Delta Outflow. Other important considerations are governance, adaptive management, and climate change. Table 169 illustrates the affected life stages, primary stressors/effect pathways, and relevant management actions by CVP and SWP division or waterbody.

Table 169. Affected life stages, primary stressors/effect pathways, and relevant management actions by Central Valley Project/State Water Project division or waterbody.

Division/Water body	Seasonal Operations Period	Affected Life Stage	Summary of Primary Stressors and Effects of the Proposed Action	Relevant Management Actions
Sacramento River	Fall and Winter Operations	Incubating eggs and Juveniles	Stranding and Dewatering ● up to 4,375 juveniles per year ● Up to 1 redd per year	Ramping rates, fall and winter baseflows for Shasta Refill and Redd maintenance
Sacramento River	Fall and Winter Operations	Juveniles	Out-migration cues, juvenile growth and survival ● Survival effects during out-migration	Winter base flows and pulse flows
Sacramento River	Spring Operations	Migrating and Holding adults	Pathogens and disease, pre-spawning mortality ● up to 5.5% female pre-spawning, although less than 3% expected	Adult Migration Holding Temperature Objectives
Sacramento River	Spring Operations	Adult spawning	Spawning Habitat ● Amount and location of spawning habitat ranges managed in relation to the CCR gauge based on Bin Objectives	Shasta Framework, annual Temperature Management Plans, technical and policy team coordination during real-time operations, and adaptive management

Division/Water body	Seasonal Operations Period	Affected Life Stage	Summary of Primary Stressors and Effects of the Proposed Action	Relevant Management Actions
Sacramento River	Spring Operations	Incubating eggs	Redd Quality ● Quality of spawning habitat conditions managed in relation to the CCR gauge based on Bin Objectives	Shasta Framework, annual Temperature Management Plans, technical and policy team coordination during real-time operations, and adaptive management
Sacramento River	Spring Operations	Juveniles	Out-migration cues ● Survival effects during out-migration	Pulse flows
Sacramento River	Summer Operations	Adult spawning and egg incubation	Water temperature, pathogens and disease ● Affected by Shasta Framework based on Bin Objectives	Shasta Framework, annual Temperature Management Plans, technical and policy team coordination during real-time operations, and adaptive management
Sacramento River	Summer Operations	Adult spawning	Spawning habitat ● Affected by Shasta Framework based on Bin Objectives	Shasta Framework, annual Temperature Management Plans, technical and policy team coordination during real-time operations, and adaptive management
Sacramento River	Summer Operations	Incubating eggs	Redd quality ● Affected by Shasta Framework based on Bin Objectives	Shasta Framework, annual Temperature Management Plans, technical and policy team coordination during real-time operations, and adaptive management
Delta	Summer and Fall Operations	Juvenile rearing and out-migration	Routing and entrainment risk at the Delta Cross Channel ● Risk of entrainment at the Delta Cross Channel in November for early migrating juveniles when gates open	Delta Cross Channel Closures, technical and policy team coordination during real-time operations, and adaptive management
Delta	Summer and Fall Operations	Juvenile rearing and out-migration	Routing into Central and South Delta and entrainment at export facilities ● Risk of routing and entrainment in November for early migrating juveniles	OMR (Old and Middle rivers) Flow Management (winter-run early season migration action)

Division/Water body	Seasonal Operations Period	Affected Life Stage	Summary of Primary Stressors and Effects of the Proposed Action	Relevant Management Actions
Delta	Winter and Spring Operations	Juvenile rearing and out-migration	Routing and entrainment risk at the Delta Cross Channel ● Risk of entrainment at the Delta Cross Channel from December 1 to January 31 if gates are opened for D-1641 water quality actions	Delta Cross Channel Closures, technical and policy team coordination during real-time operations, and adaptive management
Delta	Winter and Spring Operations	Juvenile rearing and out-migration	Routing and entrainment risk into the Central and South Delta ● Risk of salvage and loss at the state and federal export facilities ● Risk of predation and other sources of mortality in the entrainment footprint ● Potential risk from implementing the storm flex action	OMR Flow Management ● Juvenile Production Estimate as a tool for scaling loss triggers to population size ● Winter-run Early Season Migration Action ● Start of OMR Management ● Real-time adjustments ● Weekly distributed loss thresholds ● Seasonal loss thresholds ● Storm flex protective criteria
Delta	Winter and Spring Operations	Juvenile rearing and out-migration	Spring Delta Outflow ● Potential to use this action to reduce entrainment risk	● Spring Delta Outflow Action and governance through technical and policy teams to schedule volumes

9.1.2.1. Water Temperature Management Under the Shasta Framework: Egg Incubation and Emergence Temperature Objectives

The winter-run Chinook salmon population in the mainstem Sacramento River persists mainly because of water released from Shasta Reservoir during the summer (National Marine Fisheries Service 2014b). This ESU spawns during the summer months when air temperatures usually approach their warmest, and the temperature regime is expected to become more challenging under a range of assumptions about climate change. Recent droughts have highlighted the challenge and the elevated risk that SR winter-run Chinook salmon face during critically dry years, especially when critically dry years occur in succession as they did in 2014 and 2015 and again in 2020 and 2021. Reclamation, therefore, proposes a new Shasta temperature and

management framework to provide increased drought protection and maximize suitable temperature regimes for SR winter-run Chinook salmon.

The Shasta Framework establishes biological objectives and drought protection mechanisms for each of the framework's three bins that are based, in part, on February, March, and April forecasts for end-of-August and end-of-September storage based on conservative exceedances. Specific mechanisms may differ depending on the Bin and the detailed circumstances of the water year and real-time conditions, but they all serve to reinforce end-of-September storage objectives, which have a direct influence on water temperature management, TDM, and the following year's end-of-August storage.

A critical component of the new Shasta Framework is the aggressive approach to actions in Bin 3b years. In years when end-of-August storage is expected to be less than 3 MAF, end-of-September storage is expected to be less than 2 MAF, and inflow to Shasta is less than 2.5 MAF, and it is determined to be a critical year, SRSC diversions will be limited to between 75 and 50 percent to achieve an end-of-September storage of 2.0 MAF. This is an important drought response compared to current operations where supply is reduced to 75 percent and will provide much-needed storage and cold water supply for managing stressed conditions.

The Shasta Framework also leverages the integrated work of the SHOT and the SRG to achieve new operational and biological goals and objectives that will have the effect of reducing TDM for SR winter-run Chinook salmon. The high-level purpose of the SHOT is to ensure agency interaction and coordination on the Sacramento River and also with the broader CVP and SWP system, but it will also work closely with the SRG on technical and policy matters surrounding actions that are necessary to implement the Shasta Framework. The SHOT also introduces a new planning approach wherein the processes and actions of the technical and management teams are closely tied to the seasons of each water year, with real-time system considerations and planning decisions being made on a monthly or bi-weekly basis depending on the level of risk or time of year. This process will introduce more conservative planning and more definitive actions taken to protect SR winter-run Chinook salmon in the Upper Sacramento River.

NMFS estimates that in Bin 1 years, which are expected to occur in 80 percent of years, Reclamation's management of Shasta's cold water pool will support an average modeled temperature-dependent egg survival that is approximately 97 to 99 percent (50th and 80th percentile). Bin 2 years are expected to occur in 11.5 percent of years. Reclamation's management of Shasta's cold water pool will support an average temperature-dependent egg survival of 95 to 97 percent in Bin 2a years, and an average of 90 to 93 percent in Bin 2b years. In Bin 3 years, which occur in 8.5 percent of years and are highly variable, median survival ranges from nearly zero to nearly 100 percent. The median survival in Bin 3a years is about 70 percent, while Bin 3b is nearly 20 percent.

There is a 7-percent increase in survival across all years and a 13-percent increase across all critical years over conditions in the Environmental Baseline, as represented in the NAA modeling. However, concerns remain regarding temperature extremes during critical years. Consecutive dry years (e.g., 2020–21, 2014–15, 1992–94, 1977–79, and 1931–1934) are exceptionally dangerous to egg incubation for multiple year classes, with TDMs in the 60 to 100 percent range. These conditions will rely heavily on real-time operations and decision-making to minimize the impact of these adverse events on SR winter-run Chinook salmon.

During drier water years, the SRSCs will meet and confer with Reclamation, NMFS, and other

agencies as appropriate to determine if there is a role for the SRSCs in connection with Reclamation's operational decision-making for Shasta Reservoir annual operations in those years. This determination will include consideration of what actions are feasible, consistent with the terms of the SRS Contracts and would also lead to the desired outcome. NMFS expects that Shasta Framework actions will minimize mortality and are expected to help build storage in Shasta Reservoir. Although SRSC actions are voluntary in nature, there is a strong history of coordination and implementation of actions as demonstrated by the progress that has been made through implementation of their Sacramento Valley Salmon Recovery Program, and this opinion considers these voluntary commitments as contributions.

9.1.2.2. Fall and Winter Baseflows for Shasta Refill and Redd Maintenance

Another important component of the proposed action is fall and winter base flows that are used as a tool to refill storage at Shasta Reservoir to increase the likelihood that cold water will be available for temperature management the following year. Water temperature is a highly ranked threat to SR winter-run Chinook salmon, as described in the NMFS salmonid recovery plan (National Marine Fisheries Service 2014b), and actions that address this threat are important to reduce the potential adverse effects of summer water temperatures. These fall flow reductions would contribute to lower river flows in the mainstem Sacramento River, which has the potential to reduce juvenile survival during rearing and downstream migration. However, the proposed action also increases the frequency and duration that Reclamation will release water from Shasta Reservoir to provide storage for flood control, and these releases will increase downstream flows compared to current operations. Out-migrating juveniles will benefit from a 2- to 5-percent increase in survival under the proposed action, mainly as a result of increased frequency of spilling at Shasta, but still experience relatively low out-migration survival (11 to 26 percent) because seasonal operations capture many natural spring pulses, reducing juvenile out-migration cues, rates, and survival.

9.1.2.3. Sacramento River Pulse Flows

Sacramento River Pulse Flows will be implemented to improve the survival of juvenile Chinook salmon. They will typically occur during spring months, but the SRG and the SHOT may propose or consider other timing options if there is a high-value multi-species benefit. Pulse flows that are better timed to overlap with SR winter-run Chinook salmon out-migration would help to partially improve lower survival rates.

9.1.2.4. Operation of the Delta Cross Channel Gates

Another important component of the proposed action that would affect the survival of SR winter-run Chinook salmon is the potential for routing through an open Delta Cross Channel into interior Delta routes with lower through-Delta survival compared to survival observed in fish that remain in the mainstem Sacramento River or travel via Sutter Slough or Steamboat Slough. However, Reclamation would continue to use real-time information (Knights Landing and Sacramento River catch indices) to close the gates during October and November, limiting the likelihood of juvenile Chinook entrainment into the Delta Cross Channel and, thereby, into the interior Delta. Starting in December, the default operation is to close the Delta Cross Channel gates based on seasonal migration timing and the expectation that salmonids will more frequently be present near the Delta Cross Channel. This would negatively impact a relatively

small proportion of the population while protecting the survival of a relatively high proportion of emigrating juvenile Chinook salmon from the mainstem Sacramento River and Battle Creek spawning populations.

9.1.2.5. Old and Middle River Management and Entrainment and Loss at the Delta Export Facilities

Pumping water from the South Delta export facilities is another major component of the proposed action that would affect SR winter-run Chinook salmon. OMR flow management is used to reduce entrainment of fish, including SR winter-run Chinook salmon, into the southern Delta and the loss of fish at the export facilities. OMR management includes multiple action components that target different seasons and species. There are several action components developed for salmon and steelhead that manage OMR flows for the purpose of minimizing salvage and loss at the CVP and SWP export facilities, including:

- **Winter-Run Early Season Migration:** To minimize entrainment and salvage of early-migrating SR winter-run and CV spring-run Chinook salmon in November and December by reducing exports when genetically verified triggers are exceeded based on a proportion of the SR winter-run Chinook salmon JPE.
- **Start of OMR Management:** The OMR management season begins either on December 1 or December 20, depending on certain smelt protection actions being triggered. Once the OMR management season starts, the OMR index, on a 14-day running average, will be no more negative than -5,000 cfs until the end of the OMR season.
- **Winter-Run Chinook Salmon Annual Loss Threshold:** This element is intended to keep annual loss from exceeding certain historical levels. OMR flows are adjusted to be less negative when thresholds are exceeded, which is intended to help curb escalating levels of loss.
- **Winter-Run Chinook Salmon Weekly Distributed Loss Threshold:** This element is intended to minimize the potential for disproportionate impacts of entrainment on any single week that natural SR winter-run Chinook salmon are in the Delta.
- **Storm Flex:** This action could potentially offramp the -5,000 cfs to be no more negative than -6,250 cfs prior to the last day of February.
- **End of OMR Management Season:** OMR management season concludes on June 30 or when water temperatures at Mossdale and Prisoner's Point exceed 71.96°F for 7 non-consecutive days; whichever happens first.

Several of the action elements described above including the Winter-Run Early Season Migration, the weekly distributed loss thresholds, the use of genetic confirmation to initiate action triggers, and the addition of a new temperature compliance point will provide more conservative offramping to end the season.

The zone of influence for the effects of this component of the proposed action is concentrated in the South Delta, where populations of the Southern Sierra Nevada diversity group would have the greatest exposure. Populations entering the Delta via the Sacramento River, such as SR winter-run Chinook salmon, are less exposed to these effects as the extent of hydrodynamic influence of Delta export operations diminishes with distance from the export facilities.

For SR winter-run Chinook salmon (which is comprised of one population and diversity group), exposure to this component of the proposed action would occur from December through June,

with 100 percent of the population exposed to potential routing influence at junctions, but is limited to those individuals whose migration route includes Georgiana Slough, which is expected to be about 15 to 20 percent of the population. Those individuals would experience the interior Delta conditions affecting migration timing, and a fraction may enter the zone of influence and possibly be salvaged at the South Delta export facilities. This opinion considers through-Delta survival as a surrogate for the proportional effects of this element of the proposed action.

Under current operations (NAA), salvage ranges from 75 fish in critical years to 2,428 in wet years, and under the proposed action scenario (Alt2v1), the range is 67 to 2,493, which is slightly lower in critical years and slightly higher in wet years. In the context of through-Delta survival under current operations and the proposed action, through-Delta survival ranges from no difference in survival for above normal, below normal, dry and wet water years to an increase in survival under the proposed action of 1 percent in critical water years.

Under the proposed action, OMR management is intended to provide similar types of protection but with more spatially resolved tracking (e.g., weekly loss thresholds rather than just seasonal, which is expected to result in reduced fish loss during peak migration). Additionally, for SR winter-run Chinook salmon, the tracking is tailored to genetic SR winter-run Chinook salmon. These components may result in fewer real-time OMR restrictions but should still provide protections when genetic SR winter-run Chinook salmon are observed in salvage and would improve the ability to protect individuals at the front and tail end of the migration period, which helps to preserve life history diversity.

Reclamation's modeling does not reflect the operation of the Georgiana Slough Juvenile Migration Barrier that was initially installed in the late winter of 2024 and will be operated pursuant to the CDFW's 2024 ITP (California Department of Fish and Wildlife 2024c) through November of 2034. Early evaluations of this barrier have demonstrated that it is effective in deterring juvenile salmonids exposed to the Sacramento River-Georgiana Slough junction from entering the Central and South Delta. The effectiveness of this barrier will be monitored and adjusted to optimize performance through the ITP's adaptive management program. This action is expected to further reduce entrainment beyond modeled estimates.

9.1.2.6. Spring Delta Outflow

This element of the proposed action is specific to the proposed pre-adoption period of the Delta component of the VAs, which is a 2-year volumetric export reduction action but qualitatively considers DWR's proposal to implement export reductions based on San Joaquin River flows measured at Vernalis until the post-adoption period of the Delta component of the VAs. The action is proposed for dry, below normal, and above normal water years and not proposed in critical and wet years. Because the zone of influence for the effects of this element of the proposed action is centered in the South Delta, populations of salmonids entering the Delta via the Sacramento River, such as SR winter-run Chinook salmon, would be less exposed to the effects of this element.

For SR winter-run Chinook salmon (one population/diversity group), exposure to this element of the proposed action would occur from March through April, with about 25 percent of the population exposed. Reduced routing and entrainment during Spring Delta Outflow export reduction can result in decrease in modeled salvage of up to 47-percent during implementation of the export reduction. These conditions are expected for the first 2 years of implementation, with

some, lesser degree of this improvement continuing as a result of DWR's commitment to manage spring outflows until VAs are in place. Reclamation may continue this pre-adoption action for longer than 2 years if substantial progress is being made to approve VAs, but they are not yet incorporated in the SWCB's WQCP.

9.1.2.7. Governance and Adaptive Management

The Governance element of the proposed action describes the proposed engagement of participating state and federal agencies, interested parties, and the public and how they will work together during implementation. Governance establishes the teams and principles that are subject to ongoing collaborative implementation and decision-making, identifies the processes for working together, and establishes protocols for elevating and resolving matters when there is a lack of consensus. For such a large and complicated project, Governance is essential for ensuring implementation is carried out as described in the proposed action, including the complicated interface between real-time operations and the ongoing technical and management discussions that inform operations and species protections, and that it remains within the bounds of the analysis in this opinion.

The proposed action also includes an AMP as a structured, iterative process for decision-making when confronted with uncertainty. Adaptive management emphasizes learning through management where knowledge is incomplete and provides a process for building knowledge through monitoring and science, reducing uncertainty, and improving management over time in a goal-oriented and structured way. The AMP and related special studies include over 20 actions, and while they may not individually or collectively change project-related effects on SR winter-run Chinook salmon, they are expected to improve management and to inform actions that affect species risk.

9.1.2.8. Life Cycle Modeling

Life cycle model results were considered for the proposed action, as well as the current operations scenario (NAA) which is a representation of the past discretionary and non-discretionary effects of project operations. The life cycle modeling also included an analysis of the obligated release scenario, which only focuses on past and future non-discretionary effects. This section focuses on modeling for the proposed action and the current operations.

Overall, many of the models indicated a similar direction of effect, if not magnitude of effect. Specifically, for the IOS model and the SWFSC's WRLCM, proposed action results relative to the current operations scenario showed little difference in egg and fry survival for most year types except critical water years where SR winter-run Chinook salmon egg and fry survival were lower under the proposed action compared to current scenario. These results, however, reflect CalSim 3 modeling and not the CalSim 2 modeling that was used to develop the Shasta Framework. Following agency discussions during the consultation process that indicated that the CalSim 3 results are inconsistent with the Shasta Framework, Reclamation restated their commitment to the Shasta Framework TDM objectives, so we therefore expect that the egg survival would improve over what is shown in the LCM results. The IOS modeling also shows small (less than 1 percent) differences for in-river and through-Delta survival between the proposed action and current operations. Ultimately, the IOS predicted that the mean SR winter-run Chinook salmon female escapement by water year type showed slightly higher female escapement under the proposed action scenario relative to current operations.

The WRLCM showed that the proposed action modeling scenarios resulted in a mean percent change in CRR that is approximately 13 to 15 percent higher than current operations. In the model runs, estimates of the difference in CRR for 1,000 paired runs of the WRLCM indicate that there is a 99 to 100 percent probability that CRR would be higher for the proposed action scenarios relative to current operations. This indicates that the population's ability to replace itself is increased for the proposed action scenario compared to current operations.

9.1.2.9. Programmatic Actions

The opinion includes certain action components that were analyzed as framework-level programmatic actions for the development of future actions that may be authorized, funded, or carried out at a later time, and any take of a listed species would not occur unless and until those future actions are authorized, funded, or carried out and subject to further ESA section 7 consultation. We analyzed the effects of those actions qualitatively for the purpose of understanding how they might be carried forward in the context of water operations. The following framework programmatic actions are considered in this opinion:

- The Sites Reservoir Project: Adverse and beneficial effects to listed species and designated critical habitat. A broad suite of potential effects to individuals and PBFs of designated critical habitat are proposed to be minimized or avoided through established guiding principles, best management practices, adaptive management strategies, and monitoring and compensatory mitigation strategies. Project components include bypass and pulse flow criteria, monitor and mitigate the effects of diversions, habitat restoration, and use of the best available science to develop and implement operations plans.
- The Delta Conveyance Project: Adverse and beneficial effects to listed species and designated critical habitat. A broad suite of potential effects to individuals and PBFs of designated critical habitat are proposed to be minimized or avoided through established guiding principles, best management practices, adaptive management strategies, and monitoring and compensatory mitigation strategies. Project components include bypass and pulse flow criteria, monitor and mitigate the effects of diversions, habitat restoration, and use of the best available science to develop and implement operations plans.
- Spring Outflow - Post-Adoption of VAs: This action is expected to result in improved flow conditions and reduced entrainment for listed species in the Delta during April and May and improved survival over baseline for rearing and migration. These responses are consistent with the objectives of the long-term operations of the CVP and SWP to implement actions that reduce entrainment and improve survival through the Delta. These responses would mostly affect juvenile fish in particular, as they are most susceptible to entrainment and flow-related survival. There may also be some responses to juvenile rearing and survival during spring months on the Sacramento and American rivers during certain water year types. Risks to listed species are low.
- Drought Response (i.e., Drought Toolkit): The Drought Response action includes components designed to avoid or mitigate the effects of drought. A drought planning team will evaluate the need for drought actions annually and propose them on a case-by-case basis. Given the framework-level programmatic nature of this action, it is possible to estimate the specific impacts but the overall objective is to consider and implement actions that avoid or mitigate drought-related consequences to listed species and their critical habitat.

- Monitoring: Many ongoing monitoring programs that inform operational actions and effects are currently under existing and separate ESA section 7 consultations and section 10(a)(1)(A) permits and considered in the Environmental Baseline section of this opinion. Potential future changes to monitoring programs associated with the operation of the CVP and SWP will be addressed in separate ESA section 7 consultations that are tiered to the consultation. Subsequent changes to existing monitoring programs would be coordinated and included in future consultations of the LTO of the CVP and SWP to allow for a more uniform analysis and improved accounting of incidental take coverage associated with the operation of the CVP and SWP.
- Tidal Habitat Restoration: Tidal habitat restoration will result in near-term impacts to aquatic and riparian habitat leading to lethal and sublethal impacts to listed species, but the risks to individuals will be avoided, minimized and mitigated through long-established best management practices. Post-construction habitat conditions will benefit the growth and survival of listed species and improve the conservation value of critical habitat.
- Adaptive Management and Special Studies: The Adaptive Management Program will utilize decision support tools such as structured decision-making to improve future management decisions to improve the operations of the CVP and SWP for project purposes. Most of the actions will improve the are intended to improve the capacity and precision of the projects to protect listed species.

9.1.2.10. Winter-Run Action Plan

The WRAP was developed collaboratively among representatives from Reclamation, NMFS, USFWS, DWR, CDFW, and the SRSCs as an integrated plan to improve the survival and viability of SR winter-run Chinook salmon that functions alongside the planned operation of Shasta Reservoir. The WRAP is specifically connected to SR winter-run Chinook salmon through the Shasta Framework as a mechanism to improve the overall viability of the ESU. The WRAP was not developed to address conservation concerns of other species although it may serve as a useful partnership to model. The WRAP includes a list of six high-priority actions to reduce the stressors to SR winter-run Chinook salmon through a combination of science, fishery actions, infrastructure improvements, and reintroduction to historic habitat. The plan priorities include:

1. Thiamine Deficiency Complex Management
2. Reintroduction into Battle Creek and McCloud River
3. Early Life Stage Survival Science
4. Temperature Control Device Infrastructure Improvement at Shasta Dam
5. Modernization of the LSNFH
6. Habitat Restoration and Facility Improvements

9.1.3. Climate Change Considerations

As previously described in this opinion, SR winter-run Chinook salmon egg and fry stages are vulnerable to warmer water temperatures during the summer, and therefore particularly at risk from warming conditions due to climate change. The only remaining population of SR winter-run Chinook salmon relies on the cold water pool in Shasta Reservoir, which buffers the effects

of warm temperatures in most years. The exception occurs during drought years, which are predicted to occur more often with climate change.

The BA results, which characterize climate change conditions to 2037, provide an estimate of projected temperature and precipitation changes that are reasonably consistent with California's Fourth Climate Change Assessment. The proposed action routinely uses conservative hydrologies and forecasts to inform operations and species protections.

As described above, the goals of the Shasta Framework for water temperature management and storage are to provide increased drought protection and maximize suitable temperatures for SR winter-run Chinook salmon. The Shasta Framework includes drought protection actions for nearly every year and identifies actions that will protect storage. The strategy is built around and informed by an objectives-based management strategy developed from a multi-year drought sequence that occurred in Victoria, Australia (Mount et al. 2016) and applies a conceptual approach to protect SR winter-run Chinook salmon during droughts when conditions are stressed; recover and maintain species conditions when hydrologic conditions are not stressed but may be moderately limited; and to enhance species conditions when hydrologic conditions are good and water resources are not stressed or are less limited.

The DRY Team will convene on an annual basis, centered around the start of each water year, to assess the need for drought response actions, which may be elevated to WOMT in water years where hydrology or water storage (e.g., drought) present challenging water management decisions that cannot be fully addressed by annual operations planning. In those years the DRY Team will coordinate and review potential Drought Toolkit actions meant to avoid or mitigate drought impacts. As a primary tool of the DRY Team, and as a resource for managers (e.g., SHOT and WOMT), the Drought Toolkit is an approach by which the DRY Team may coordinate with the SHOT and WOMT to recommend and evaluate the implementation of drought actions. At the time of this consultation, there are 25 drought response actions that are included in the Drought Toolkit, however, more may be added as new approaches and actions are developed to address future drought conditions. While these are not necessarily prescriptive actions implemented based on triggers, they are expected to play a role in offsetting or minimizing impacts to SR winter-run Chinook salmon during drought periods.

Although not as prescriptive as the Shasta Framework, the WRAP will convene policy, technical and scientific focus on priority actions that are expected to improve the status and viability for SR winter-run Chinook salmon over the next 10 years. Priority actions in the WRAP for reintroduction to the McCloud River and modernization of the LSNFH are actions that will help build further resilience for the species in the face of a changing climate.

9.1.4. Risk to Sacramento River Winter-Run Chinook Salmon at the ESU-Level

The SR winter-run Chinook salmon ESU currently comprises one population that resides in only one diversity group in California: the Basalt and Porous Lava Diversity Group. The population currently faces a high risk of extinction that is driven by high levels of hatchery influence; threats from disease; predation; habitat loss, alteration, and degradation; and is particularly susceptible to climate change and drought (National Marine Fisheries Service 2024a). There are ongoing efforts to reintroduce SR winter-run Chinook salmon to Battle Creek and to the McCloud River, but to date, there are no established populations in these areas.

This proposed action was developed in a collaborative setting between Reclamation, USFWS, CDWR, CDFW and NMFS. It includes components that have been developed over the last 15 years, as well as components intended to reconcile measures provided in the NMFS's October 21, 2019 opinion on the LTO of the CVP and SWP with the State's March 31, 2021 ITP for LTO of the SWP. The topics that were addressed in the process include:

- Operation of Shasta Reservoir for Outflow and Cold Water Pool Management
- Delta operations for fish migration, recruitment, and survival
- Incidental take
- Agency roles in decision-making
- Adaptive Management
- Exploration of additional measures and actions that support fish species and reduce extinction risk

Some of the updates include refined approaches for managing temperatures and storage at Shasta; improved processes for technical, scientific, and policy coordination which should provide more responsive decision-making when Shasta or Delta conditions are stressed; refined approaches for managing OMR with weekly loss triggers that should allow for more careful management of loss during periods of periodically high salvage; and using genetics to more precisely inform SR winter-run Chinook salmon decision making.

Regardless of the iterative improvements, the proposed action will continue to result in ongoing adverse effects to SR winter-run Chinook salmon. The most significant adverse effects, as described throughout this opinion, are temperature dependent egg mortality that will occur in Bin 3 conditions. During Bin 3 conditions, the SHOT will track and may take numerous early actions to minimize the severity of impacts to be less than the modeled results. Under the current operations plan, collaborative water temperature management and storage planning do not commence in earnest until the spring, with a few exceptions consistent with the SRS resolution. Under the proposed action, the collaborative planning groups meet on a frequent schedule that centers around the beginning of the water year. Notably, the five-agency SHOT will work with technical and scientific groups to develop JPEs, conduct an SR winter-run Chinook salmon brood year assessment that will be used as an annual status to track the species condition, and take appropriate and timely action to avoid or minimize impacts to the following year's cohort. If the previous year's cohort and the cohort 3 years prior are determined to be in an "adverse condition" as defined in the proposed action, then more actions would be taken to manage biological and drought protection objectives described in the proposed action. This proactive planning, although procedural in nature, is expected to yield real-time results that will improve the management of temperature of storage-related impacts on SR winter-run Chinook salmon survival.

There remain significant concerns regarding survival in certain Bin 3b years when the system is stressed, and there may be periods of significantly low temperature-dependent survival of SR winter-run Chinook salmon such as the consecutive dry years seen in the modeled CalSim years of 2020–2021, 2014–2015, 1992–1994, 1977–1979, and 1931–1934, which show very high egg mortality for multiple year classes, with TDMs in the 60 to 100 percent range. In the 2020 and 2021 drought years, agencies worked together to increase the production of SR winter-run Chinook salmon at the LSNFH as part of the Integrated Recovery Supplementation Program. The LSNFH Integrated Recovery Supplementation Program is a small and highly respected

conservation hatchery that operates under a closely managed scientific structure that maintains the genetic and life history diversity of the ESU while providing important recovery-based supplementation of fish to the naturally produced population in the river. Supplementation decisions are now integrated into the proposed action through the SHOT team which will allow more coordinated and proactive response to managing supplementation, especially during the drought years or when SR winter-run Chinook salmon are predicted to be in "adverse condition" as described above. Although actions to increase hatchery production result in proportionally higher levels of hatchery fish in the ESU, which influences the extinction risk for the species, history has shown that the proportion of hatchery fish in the population tends to decline following high supplementation years and increased supplementation has, on more than one occasion, avoided irretrievable impacts to the species in terms of its abundance, production, and diversity. Thus, it remains an important and effective tool for protecting and conserving SR winter-run Chinook salmon when the Shasta system is highly stressed in Bin 3 years and SR winter-run Chinook salmon are in "adverse conditions."

Downstream, the proposed action will result in adverse effects related to routing into the Central Delta through the Delta Cross Channel and near and far-field effects from project-related changes in Delta hydrodynamics. At the Delta export facilities, operations of the CVP and SWP pumps will result in entrainment into the export facilities where fish can be injured and/or lost to predation and other factors. While Reclamation and DWR's discretionary impacts to SR winter-run Chinook salmon are higher than under the obligated release scenario, the modeled impacts on the species indicate the impacts of the proposed action will not be substantially different than current operations. Refinements to loss management include weekly loss thresholds that will reduce the potential for instantaneous spikes in salvage before actions are taken to minimize the zone of influence that may be driving salvage and loss. Spring Delta Outflow actions, while not having a large influence on SR winter-run Chinook salmon, will provide modest reductions in salvage and loss.

The proposed action includes measures to address the effects of climate change and drought including the Shasta Framework, with new operational and biological objectives, an improved process for governance and decision-making, use of conservative forecasts to make operational decisions, and the continued use of a Drought and Dry Year Actions toolkit. The strategy to proactively address future drought conditions will improve the effectiveness of maintaining SR winter-run Chinook salmon abundance and productivity in high-risk years, but more importantly, it may reduce the frequency of being at high risk through numerous drought abatement actions.

As described in the Analytical Framework of this opinion, the risk to the SR winter-run Chinook salmon ESU posed by the proposed action is evaluated in the aggregate context of the species' status, the environmental baseline, cumulative effects, and effects from other actions. Because the ESU is composed of one population, the effects of, and risks associated with, the proposed action at the population level also represent the risks at the ESU level. In total, NMFS expects that despite ongoing adverse effects of the CVP and SWP on individuals and their respective populations and the continued and significant adverse effects that are part of the environmental baseline such as the loss of historical habitat related to the physical presence of Keswick and Shasta dams, the proposed action also includes measures intended to maintain the abundance, productivity, and diversity, and may improve the spatial structure of the ESU.

NMFS has finalized recovery planning for the SR winter-run Chinook salmon ESU (National Marine Fisheries Service 2014b). Several components of the proposed action are aligned with or

directly implement recovery actions identified in the recovery plan. Examples include, but are not limited to:

- Establish partnerships and agreements that promote water transactions, water transfers, shared storage, and integrated operations that benefit both species needs and water supply reliability in the Central Valley
- Develop and implement a river flow management plan for the Sacramento River downstream of Shasta and Keswick dams that considers the effects of climate change and balances beneficial uses with the flow and water temperature needs of SR winter-run Chinook salmon, CV spring-run Chinook salmon, and CCV steelhead
- Modify Delta Cross Channel gate operations and evaluate methods to control access to Georgiana Slough and other migration routes into the Interior Delta to reduce diversion of listed juvenile fish from the Sacramento River and the San Joaquin River into the southern or central Delta
- Reduce hydrodynamic and biological impacts of exporting water through Jones and Banks pumping plants
- Minimize the frequency, magnitude, and duration of reverse flows in OMR to reduce the likelihood that fish will be diverted from the San Joaquin or Sacramento rivers into the southern or central Delta
- Improve the timing and extent of freshwater flow to the San Francisco Bay region to the benefit of juvenile and adult salmonids by modifying water operations in the Central Valley to support flows that mimic the natural hydrograph
- Improve temperature management and flow measures at CVP facilities and tributaries

The assessment of risk also considers VSP parameters as summarized in Table 170.

Table 170. Summary of Viable Salmonid Population (VSP) parameters considered in the analysis of effects.

VSP Parameter	Proposed Action Considerations	VSP Considerations
Abundance	Shasta Framework: Juvenile Production Estimate (JPE), brood year assessments, Bin determinations and annual biological objectives, Seasonal pulse flows, ramping rates, and Winter-Run Action Plan (WRAP). Delta Operations: JPE-based OMR (Old and Middle rivers) triggers and actions, risk assessments	The proposed action includes measures to protect early life stage survival and abundance of the only Core 1 population of Sacramento River (SR) winter-run Chinook salmon in the evolutionarily significant unit in the Sacramento River downstream from Shasta and Keswick dams. Use of the Livingston Stone National Fish Hatchery (LSNFH) supports maintenance of larger population size and resilience, especially during Bin 3 conditions. The proposed action is designed to respond to variable population sizes and take action when population trends are determined to be adverse based on an annual brood year assessment. At Shasta, the majority of years will be managed to Enhance and Maintain populations through dynamic approaches to water temperature management. When conditions are limited, they will be managed to protect the species through adjusted temperature management strategies. Another example of managing to variable population sizes is Reclamation's proposal to use the SR winter-run JPE for developing weekly and annual loss thresholds that are scaled to annual juvenile population size for OMR management. The effects analysis found that in most years the early life stage survival in the upper river is high. There are certain years where survival is compromised. The Shasta Framework is carefully crafted to respond to these conditions with several approaches including Bin-specific operational and biological objectives and use of the LSNFH Integrated Recovery Supplementation Program when conditions are expected to negatively affect in-river survival. The WRAP has priorities that are expected to improve the abundance of SR winter-run Chinook salmon over the next 10 years. We expect the proposed action to improve the abundance of SR winter-run Chinook salmon over baseline conditions to the extent that improved temperature management objectives reduce temperature-dependent mortality during the most critical periods.
Productivity	Shasta Framework: JPE, brood year assessments, Bin determinations and annual biological objectives, WRAP Delta Operations: JPE-based OMR triggers and actions, risk assessments	Productivity considerations are integrated into the development of an annual JPE that informs brood year strength for both Shasta and Delta Operations. Delta entrainment metrics are adjusted annually based on population productivity. SR winter-run Chinook salmon production tends to be higher in wet years and compromised in drier years—particularly back-to-back droughts. The Shasta framework is designed to address the risk and significance of drought effects but production can still be adversely affected in dry years.

VSP Parameter	Proposed Action Considerations	VSP Considerations
Diversity and Spatial Structure	Sacramento River: Shasta Framework and downstream extent of temperature management based on Bin type and biological objective, WRAP and reintroduction priorities. Strategic use of the LSNFH Integrated Recovery Supplementation Program and its Hatchery Genetic Management Plan. Delta: Use of annual and weekly loss thresholds, weekly risk assessments	The Shasta Framework considers the spatial structure and distribution of spawning habitat availability and seeks to manage that on an annual basis depending on Bin type. In wet years, the spatial extent of spawning habitat is managed further downstream than in drier years. The WRAP seeks to expand the spatial extent of spawning habitat over the next 10 years by supporting the reintroduction of the species into historic habitats. The LSNFH Integrated Recovery Supplementation Program integrates state-of-the-art practices and maintains genetic diversity, especially during droughts but also creates concerns for long-term genetic integrity. During dry years, the spatial diversity of freshwater habitat types is adversely affected by water operations and the impacts to the abundance and productivity of populations may have adverse consequences on life history and genetic diversity.
Habitat Capacity and Diversity	Shasta Framework and application of the Victorian Objectives and Bin-specific temperature management locations	The Shasta Framework is centered around the Victorian Objectives to enhance, recover, maintain and protect. Specific biological objectives that address the spatial extent of habitat are developed annually and based on expected hydrology, storage conditions and population brood year strength. During wet years, which are expected to occur the most frequently based on CalSim 2 and 3 modeling of over 90 years of historical record, managing habitat to enhance and recover means that water temperatures will be managed further downstream with fewer exceedances than during drier years, where habitat conditions will be managed more closely to the dam and the amount and extent of usable habitat will be less.

The proposed action also does not impede the implementation of other key elements of the recovery plan, such as improving water conservation across California, incorporating ecosystem restoration in flood control planning, and improving salmon harvest monitoring and management. Implementation of the proposed action is therefore not creating conditions that would preclude recovery of SR winter-run Chinook salmon in the future. Ultimately, the viability of the SR winter-run Chinook salmon can only be improved by reestablishing them in their historical habitats upstream of Shasta Reservoir. This recovery action of reintroducing SR winter-run Chinook salmon to historic habitat upstream from Shasta Dam is moving forward through several connected endeavors, including winter-run Chinook salmon egg transfers from LSNFH to egg incubation sites along the McCloud River, survival and growth studies of juvenile SR winter-run Chinook salmon in the McCloud River, and ongoing testing of juvenile collection facilities. Although it is not an explicit part of Reclamation's proposed action over which it has full discretion, the WRAP reintroduction action is intended to improve coordination and progress to implement a phased approach to a long-term reintroduction program on the McCloud River

and is expected to improve the partnerships that are needed to maintain progress with this recovery action.

After considering its current rangewide status, the environmental baseline within the action area, the effects of the proposed action, the effects of other activities, and cumulative effects, NMFS concludes that the proposed action is not likely to appreciably reduce the likelihood of both the survival and recovery of the SR winter-run Chinook salmon ESU.

9.2. Sacramento River Winter-Run Chinook Salmon Designated Critical Habitat

9.2.1. Summary of the Status of Designated Critical Habitat

The PBFs essential for the conservation of listed SR winter-run Chinook salmon within the action area include: (1) access from the Pacific Ocean to appropriate spawning areas in the Upper Sacramento River, (2) availability of clean gravel for spawning substrate, (3) adequate river flows, (4) water temperatures for successful spawning, egg incubation, and fry development, (5) habitat areas and adequate prey that are not contaminated, (6) riparian habitat that provides for successful juvenile development and survival, and (7) access downstream so that juveniles can migrate from the spawning grounds to the Pacific Ocean.

Many of the essential PBFs of SR winter-run Chinook salmon are degraded and provide limited high quality habitat. This degradation is largely a result of the installation of Shasta and Keswick dams and other barriers in the northern region of California's Central Valley, which continue to restrict access to historical spawning habitat. Dams also reduce the suitability of downstream habitat by reducing the availability of spawning gravels, disrupting river morphology and function, altering flows, and generating unsuitable water temperatures for spawning and rearing downstream. Water diversions, shoreline armoring, and land development downstream also impair the PBFs that support juvenile rearing and out-migration by degrading and limiting access to the floodplain. The lasting impacts of habitat destruction from historical gold mining activities, as well as ongoing activities in San Francisco Bay and the Delta (including dredging, water exports, vessel traffic, and food web disruption from invasive species), continue to further limit habitat quality across the designated area.

9.2.2. Summary of Proposed Action Effects on Designated Critical Habitat

Proposed action components that affect the functioning of essential PBFs include:

- Operating CVP dam releases for flood control, temperature, and flow management, Delta water quality management, and service contract delivery
- Operating Delta facilities and managing withdrawal pumping and water exports in the Delta for service contract delivery, water quality, flow management, salmonid migration, smelt habitat, and to meet other agreement obligations
- Collaborative dry year management planning

The PBFs of designated critical habitat affected by these proposed activities are described below.

9.2.2.1. Adequate River Flows

Reclamation's proposed flow operations in the Upper Sacramento River are generally sufficient to provide for successful spawning, incubation of eggs, fry development, and emergence, and are also expected to improve spawning habitat quality compared to current conditions by mobilizing

gravels for downstream transport. However, flow operations are also expected to decrease the conservation value of the adequate river flows PBF due to insufficient flows when redds are present, resulting in increased potential for redd dewatering.

9.2.2.2. Water Temperatures for Successful Spawning, Egg Incubation, and Fry Development

Water temperatures in the reach between Keswick Dam and the CCR CDEC gauge, where most spawning occurs, have generally been sufficiently cold to support spawning in most years. However, this reach still exceeds lethal temperatures for incubating eggs during some summer months in years with lower reservoir storage. The proposed action includes cold water pool management aimed at providing suitable temperatures for spawning and incubating SR winter-run Chinook salmon, which is likely to increase the likelihood of providing water temperatures that protect eggs and fry, and is expected to maintain or expand the extent of suitable spawning and incubation habitat compared to current conditions. NMFS expects that by managing storage to improve the availability of a cold water pool in Shasta Reservoir to partially offset the effects of climate change on water temperatures and flow in the mainstem Sacramento River during summer.

9.2.2.3. Riparian Habitat That Provides for Successful Juvenile Development and Survival

Shasta Dam water operations have limited the extent of cold water rearing habitat in downstream reaches of the Sacramento River, degrading juvenile rearing habitat during summer, particularly in drier years. Flows under the proposed action would result in a decrease in juvenile rearing habitat in the Sacramento River and decreases in floodplain inundation, particularly during the September to November out-migration period in critical years.

In the Delta, the proposed flow releases that manage for water quality and smelt habitat are likely to maintain the suitability of available rearing habitat that supports juvenile development and survival.

9.2.2.4. Access Downstream So That Juveniles Can Migrate to the Ocean

Flows in the upper reach of the Sacramento River under the proposed action are generally considered sufficient for maintaining the juvenile migration corridor. Lower in the system, water diversions and managed flows limit juvenile access to floodplain habitat and side channel rearing habitats. Reclamation's proposed flows in the Sacramento River would be lower than current conditions during September to November during the peak of juvenile out-migration, reducing the quality of the PBF, particularly during critical years. Temperatures are generally considered adequate for adults during the early migration period, and the proposed temperature operations would slightly improve temperature conditions. High temperatures are likely to pose impediments to adult migration in some months of some years, although these effects may be partially offset by restoration projects that would provide additional instream cover. Unscreened diversions also impede migration by entraining juvenile fish, and while these will continue to degrade the quality of the migratory corridor under the proposed action, NMFS expects more screen improvements over time. Ongoing and future actions on Battle Creek will improve the migratory corridor, particularly with ongoing fish passage improvements associated with fish

screens and fish ladders at other dams. See Table 100 for proposed action effects to critical habitat in the Sacramento River.

In the Delta, water exports at the CVP and SWP pumping plants that reverse flows in OMR impair routing and timing for out-migrating juveniles. Water releases for the management of Delta smelt habitat are expected to provide minor improvements compared to current conditions, although the operation of control gates for these actions and other studies are expected to cause minor degradation in the quality of the corridor by impeding migration of juveniles and adults. The proposed operation of the Delta Cross Channel is expected to reduce migratory corridor habitat function by delaying juveniles and adults or re-directing them into the interior Delta. Reclamation proposes to periodically close the Delta Cross Channel gates in the late fall, winter, and spring during peak juvenile out-migration to minimize entrainment of juveniles and delay of adults. South Delta export operations will affect interior Delta conditions by exposing those juveniles present in the South Delta to salvage operations. Overall, the access downstream PBF will continue to be degraded primarily due to Delta export operations. See Table 172 for proposed action effects to critical habitat in the Delta.

Table 171. Sacramento River winter-run Chinook salmon summary of effects of the action on critical habitat.

Life Stage	Action Component	Location of Effect	Physical and Biological Features (PBFs) Affected	Response and Rationale of Effect
Spawning Adults, Incubation of Eggs, and Rearing for Fry	Spring and Summer Operations	From Keswick Dam to Bend Bridge	River Flows for Spawning, Incubation, Fry Development and Emergence, and Downstream Transport of Juveniles	Increased Spring flows are expected to provide adult holding habitat; however, higher summer flows would likely impact the aquatic food web.
Spawning Adults, Incubation of Eggs, and Rearing for Fry	Spring and Summer Operations	From Keswick Dam to Bend Bridge	Clean Gravel for Spawning Substrate	The lack of sufficient natural flows prevents the movement of gravel and sediment, leading to the formation of an "armored" riverbed dominated by cobbles with poor transport of augmented gravel in drier years.
Spawning Adults, Incubation of Eggs, and Rearing for Fry	Spring and Summer Operations	From Keswick Dam to Bend Bridge	Predicted mean proportional 80th percentile TDM estimate	Exceedance of water temperature objectives at CCR compliance point, particularly during dry and critical years, degrades adult holding, egg incubation, and juvenile rearing habitat
Freshwater Rearing Habitat for Juveniles	Fall and Winter Operations	From Keswick Dam to the Delta	Habitat and Adequate Prey that are not Contaminated Riparian Habitat for Juvenile Development and Survival	Storing water in Shasta Reservoir during the winter reduces the natural flow of the river, limiting habitat and food sources for fish, especially by preventing access to floodplains. Additionally, after artificially high flows in mid-summer, water levels drop rapidly in the fall, leaving fish eggs stranded and exposed.

Life Stage	Action Component	Location of Effect	Physical and Biological Features (PBFs) Affected	Response and Rationale of Effect
Freshwater Migratory Corridor PBFs for Out-migrating Juveniles and Spawning Adults	Fall and Winter Operations	From Keswick Dam to the Delta	Access Downstream for Juvenile Migration to San Francisco Bay and the Pacific Ocean. Access from the Pacific Ocean to Appropriate Spawning Areas	Fall and Winter flows are generally adequate to support juvenile out-migration and adult returns
PBFs for Out-migrating Juveniles and Spawning Adults	Spring and Summer Operations	From Keswick Dam to the Delta	River Flows for Spawning, Incubation, Fry Development and Emergence, and Downstream Transport of Juveniles	Spring flows support adult holding and spawning while late summer flows support juvenile out-migration

Table 172. Summary of probable change in physical or biological features of Sacramento River winter-run Chinook salmon designated critical habitat in the Delta.

Action Component	Physical or Biological Feature Affected	Response
Water transfers	Freshwater rearing sites	(1) In-river flows that provide suitable water temperature conditions in the mainstem Sacramento River. (2) Flows that provide suitable dissolved oxygen conditions through improved mixing of water column and water surface-air interface. (3) Water quality sufficient to support primary and secondary productivity, benefitting forage base. (4) Insufficient conditions for successful holding and rearing habitat for juveniles in the south Delta due to water transfers resulting in increased exports.
Water transfers	Freshwater migratory corridor	Enhanced flows from water transfers can benefit migratory habitat for juveniles migrating downstream by decreasing travel times, increasing the length of riverine reaches, and muting downstream tidal effects. Contribution of water transfers to increased exports may degrade migratory habitat in the South Delta.
North Bay Aqueduct/ Barker Slough Pumping Plant	Freshwater migratory corridor	Operations of North Bay Aqueduct/Barker Slough Pumping Plant may alter flow patterns affecting the migratory corridor PBF thereby inhibiting the mobility of juvenile listed salmonids and reducing their survival.
Delta Cross Channel Gate Closures (and Maintenance and Repair)	Freshwater migratory corridor	(1) Access to the interior Delta through open Delta Cross Channel gates reduces the survival of migrating juveniles, reducing the value of the mainstem as a suitable migratory corridor. (2) Operations of the Delta Cross Channel gates can alter the extent of tidal influence in the river reaches downstream of the Delta Cross Channel location, delaying migration or re-routing juveniles into alternate migratory routes with lower survival. (3) Operations of the Delta Cross Channel gates reduces the upstream migratory function of the mainstem Sacramento River to adults. (4) Open Delta Cross Channel gates allow entrainment into habitat exposed to the influence of the SWP and CVP export actions and reduces migratory habitat function.
Delta Smelt Summer and Fall Habitat	Freshwater rearing sites	Release of additional water from upstream to augment Delta outflow will improve water quality and enhance forage prey populations that support juvenile salmonid development.

Action Component	Physical or Biological Feature Affected	Response
Delta Smelt Summer and Fall Habitat	Freshwater migratory corridor	Release of additional water from upstream to augment Delta outflow will improve water quality and conditions supporting the mobility and survival of adult and juvenile salmonids.
Delta Smelt Summer and Fall Habitat	Estuarine areas	Release of upstream water will (1) enhance water quality, water quantity, and provide suitable salinity conditions supporting juvenile and adult salmonid physiological transitions; and (2) enhance forage prey that will support growth and maturation. Operations of the Suisun Marsh Salinity Control Gates will create temporary obstructions to free migration and potentially create predator habitat.

SR WRCS = Sacramento River winter-run Chinook salmon.

9.2.3. Risk to Critical Habitat at the Designation Level

The entirety of the critical habitat designated for SR winter-run Chinook salmon is within the action area. The essential PBFs of this critical habitat have been highly degraded by past and ongoing actions. Ongoing private, state, and federal actions and future non-federal actions are likely to continue to impair the function of PBFs and slow or limit the development of these features, with the exception of restoration actions which will offset these effects to some degree. The proposed action is expected to maintain or improve the extent of habitat with suitable water quality and flows for spawning and rearing in the Upper Sacramento River and to minimize the effects of climate change on water temperatures and summer flows during non-critical years. Spring pulse flow releases are expected to promote channel habitat-forming processes, and in combination with habitat restoration actions, are expected to offset the effects of past and ongoing flow management.

Although the PBFs of critical habitat for SR winter-run Chinook salmon have been highly degraded, the proposed action will offset some past effects of the CVP and SWP and improve others. NMFS expects the proposed ongoing operation of the CVP and SWP will improve the function of PBFs related to spawning, rearing, and migration within designated critical habitat in the action area such that the function of PBFs of critical habitat will not be significantly reduced. The proposed action is therefore not likely to appreciably diminish the value of the critical habitat for the conservation of SR winter-run Chinook salmon.

9.3. Central Valley Spring-Run Chinook Salmon

9.3.1. Summary of the Environmental Baseline, Cumulative Effects, and Status of the Species

The status of CV spring-run Chinook salmon is described in detail in the Status of the Species section of the opinion; in the Environmental Baseline section, where the status is discussed in terms of the past and present impacts of all federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed federal projects in the action area that have already undergone formal or early ESA section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process; and in the

Cumulative Effects section, that discusses the effects of future state or private activities, not involving federal activities, that are reasonably certain to occur within the action area of the federal action subject to consultation. The ESU is currently represented by numerous small populations across all four diversity groups in the Central Valley. There are approximately four Core 1, five Core 2, and three Core 3 populations and several candidate watersheds for reintroduction.

In this opinion, the effects of past CVP and SWP operations and the presence of existing structures are also part of the environmental baseline. The effects of those actions have been analyzed through past consultation and contributed to the current condition of the species and critical habitat in the action area. Other past, present, and ongoing impacts of human and natural factors (including proposed federal projects that have already undergone ESA section 7 consultation) contributing to the current condition of the species and critical habitat in the action area are also included in the environmental baseline.

Central Valley spring-run Chinook salmon are exposed to numerous cumulative effects such as unscreened water diversions, agricultural practices that impact water quality and riparian habitat, water contamination from municipal and agricultural sources, effects of urbanization, recreational and commercial fisheries, and other activities.

CDFW issued a CESA ITP to DWR for the LTO of the SWP in the Delta in November 2024 (California Department of Fish and Wildlife 2024c). Most of the actions covered in the CESA ITP are also covered in this opinion because DWR is an applicant for this consultation. One action that is not part of Reclamation's proposed action is the GSSMB. Operation of the GSSMB is expected to provide a higher probability of survival for emigrating juvenile salmonids that encounter the Sacramento River-Georgiana Slough junction and reduce entrainment of emigrating juvenile salmonids into the Central and South Delta and at the state and federal export facilities. The reduced routing effects of this action were not analyzed in the modeling for Reclamation's proposed action.

The SWFSC's midcycle viability assessment (Johnson et al. 2023b) concluded that the viability of CV spring-run Chinook salmon (through 2021) has declined since the prior viability assessment in 2016, and that the ESU's extinction risk may have increased. This ESU continues to face significant, unyielding threats that are likely to be exacerbated by the impacts of future climate change. Given that the viability of the ESU has decreased, and the threats to the species' persistence remain high and are not improving. significant habitat and flow improvement actions are urgently needed to prevent the species from going extinct and allow it to recover.

As described previously in this opinion, CV spring-run Chinook salmon reproduce and rear in Clear Creek, and they are occasionally present in the Stanislaus River. They also rear and migrate in the mainstem Sacramento River and the Delta. Current monitoring programs struggle to differentiate between CV spring-run Chinook salmon and fall-run Chinook salmon in the Sacramento River downstream of Shasta and Keswick dams.

9.3.2. Summary of the Proposed Action Effects to the Species

CV spring-run Chinook salmon are primarily exposed to project-related effects in Clear Creek, the Sacramento River, and in the Delta. CV spring-run Chinook salmon may exhibit non-natal rearing in the American River and are occasionally present in the Stanislaus River, but neither

are recognized Core populations. The effects analysis identified several proposed action components with stressors that have medium to high levels of severity, resulting in a medium to high magnitude effect for CV spring-run Chinook salmon. Major effects to CV spring-run Chinook salmon from the proposed action include Water Temperature Management under the Shasta Framework, Fall and Winter Baseflows for Shasta Refill and Redd Maintenance, Sacramento River Pulse Flows, Delta Cross Channel Gate Operations, OMR Management and Entrainment, and Spring Outflow. Other important considerations are governance, adaptive management, and climate change. The likely effects on individuals and the viability of populations in the affected diversity groups are reviewed in the following sections. Table 173 illustrates the affected life stages, primary stressors/effect pathways, and relevant management actions by CVP and SWP division or waterbody.

Table 173. Affected life stages, primary stressors/effect pathways, and relevant management actions by Central Valley Project/State Water Project division or waterbody.

Division/Water body	Seasonal Operations Period	Affected Life Stage	Summary of Primary Stressors and Effects of the Proposed Action	Relevant Management Actions
Sacramento River	Fall and Winter Operations	Adult spawning	Spawning Habitat ● Amount and extent of potential habitat affected by water temperatures that are driven by annual temperature management plans that target Sacramento River winter-run Chinook salmon. Also influenced by Bin type.	Shasta Framework, annual Temperature Management Plans, technical and policy team coordination during real-time operations, and adaptive management

Division/Water body	Seasonal Operations Period	Affected Life Stage	Summary of Primary Stressors and Effects of the Proposed Action	Relevant Management Actions
Sacramento River	Fall and Winter Operations	Incubating eggs	Redd Quality ● Amount and extent of potential habitat downstream of Sacramento River winter-run Chinook salmon temperature compliance reach expected to result in egg mortality downstream of water temperature zones in annual temperature management plans. May also occur during the month of November when the temperature management season concludes.	Shasta Framework, annual Temperature Management Plans, technical and policy team coordination during real-time operations, and adaptive management
Sacramento River	Spring Operations	Juvenile rearing and out-migration	Out-migration Cues ● Springtime survival from Deer Creek Confluence to the Feather River Confluence is expected to be 11 to 26%, from critical to wet years.	Pulse Flows, Shasta Framework, annual Temperature Management Plans, technical and policy team coordination during real-time operations, and adaptive management
Sacramento River	Summer Operations	Adult Spawning	Spawning Habitat ● Potential for dewatering of some early redds in August following peak managed releases in July.	Shasta Framework, annual Temperature Management Plans, technical and policy team coordination during real-time operations, and adaptive management
Clear Creek	Summer Operations	Upstream Migration and Adult Holding	Water temperature ● Temperatures create temporary migration barriers at confluence in July and August ● Daily average holding Temperatures at Igo exceeded in critical years, which occur 16% of years	Seasonal temperature objectives

Division/Water body	Seasonal Operations Period	Affected Life Stage	Summary of Primary Stressors and Effects of the Proposed Action	Relevant Management Actions
Clear Creek	Summer Operations	Upstream Migration	Summer instream flows ● Impaired upstream migration conditions for late-arriving adults during July and August ● Pulse flows intended to create attraction flows for adults during spring months	Instream Flow Objectives, Pulse flows
Clear Creek	Summer Operations	Juvenile rearing	Water temperature ● Suboptimal temperature in lower 3 miles (>65°F)	Seasonal temperature objectives
Clear Creek	Summer Operations	Juvenile Rearing	Stranding ● Juvenile stranding as flows recede affects small number of individuals	Ramping rates
Clear Creek	Fall Operations	Egg incubation and emergence	Water temperature ● Suboptimal temperatures in critical years is expected to cause egg mortality and reduce production	Seasonal temperature objectives, pulse flows, and minimum instream flows
Stanislaus River	All Seasons	All freshwater life stages	Effects are similar as those described for California Central Valley steelhead, however, the status of Central Valley spring-run Chinook salmon in the Stanislaus River is not well understood. The occurrence of individuals has been documented, and there is no current evidence of an extant population	Seasonal temperature objectives, pulse flows, and minimum instream flows

Division/Water body	Seasonal Operations Period	Affected Life Stage	Summary of Primary Stressors and Effects of the Proposed Action	Relevant Management Actions
San Joaquin River - Stanislaus River to Vernalis	All Seasons	All freshwater life stages	Effects are similar as those described for California Central Valley steelhead, however, the status of Central Valley spring-run Chinook salmon in the Stanislaus River is not well understood. The occurrence of individuals has been documented and recent genetic evaluations confirm (Gutierrez et al. 2024) that adults with spring-run ancestry successfully spawned in the Stanislaus River.	From the Stanislaus: Minimum instream flows, Winter Instability Flows, Spring Pulse Flows, Stanislaus Watershed Team
Delta	Summer and Fall Operations	Juvenile rearing and out-migration	Routing and entrainment risk at the Delta Cross Channel ● Risk of entrainment at the Delta Cross Channel in November for early migrating yearlings when gates open	Delta Cross Channel Closures, technical and policy team coordination during real-time operations, and adaptive management
Delta	Summer and Fall Operations	Juvenile rearing and out-migration	Routing into Central and South Delta and entrainment at export facilities ● Risk of routing and entrainment in November for early migrating juveniles	Yearling spring-run Chinook salmon surrogates

Division/Water body	Seasonal Operations Period	Affected Life Stage	Summary of Primary Stressors and Effects of the Proposed Action	Relevant Management Actions
Delta	Winter and Spring Operations	Juvenile rearing and out-migration	Routing and entrainment risk at the Delta Cross Channel ● Risk of entrainment at the Delta Cross Channel from December 1 to January 31 if gates are opened for D-1641 water quality actions. ● Risk of entrainment at the Delta Cross Channel when gates are opened for a total of 14 days from May 21 to June 15.	Delta Cross Channel Closures, technical and policy team coordination during real-time operations, and adaptive management
Delta	Winter and Spring Operations	Juvenile rearing and out-migration	Routing and entrainment risk into the Central and South Delta ● Risk of salvage and loss at the state and federal export facilities ● Risk of predation and other sources of mortality in the entrainment footprint ● Potential risk from implementing the storm flex action	OMR (Old and Middle rivers) Flow Management ● Yearling Central Valley spring-run Chinook salmon surrogates ● Young-of-year Central Valley spring-run Chinook salmon surrogates ● Future use of a Juvenile Production Estimate as a tool for scaling loss triggers to population size ● Start of OMR Management ● Real-time adjustments ● Storm flex protective criteria
Delta	Winter and Spring Operations	Juvenile rearing and out-migration	Spring Delta Outflow ● Potential to use this action to reduce entrainment risk	Spring Delta Outflow Action and governance through technical and policy teams to schedule volumes
Delta	Winter and Spring Operations	Juvenile rearing and out-migration	Agricultural Barrier Operations ● Passage impediments increase exposure to predation in May and June	Technical and policy team coordination

9.3.2.1. Water Temperature Management

Reservoir operations can influence water temperature throughout the year but are most influential on fish survival and production during the summer and fall.

Reclamation's management of Shasta Reservoir, both for water supply and for protecting the redds of SR winter-run Chinook salmon, is expected to result in mortality of eggs and fry of CV spring-run Chinook salmon downstream from Keswick Dam.

On the Sacramento River, CV spring-run Chinook salmon upstream migration cues are occasionally impaired during the summer months of drier years when water temperatures near Balls Ferry exceed conditions that do not impair upstream migration. Under the proposed action, 6.6 percent of months will be outside the 42.1°F to 55°F optimal water temperature range for minimal adult CV spring-run Chinook salmon migration impairment averaged across all water years. In wet and above normal years, no months are predicted to be outside the aforementioned range. A medium impact is projected in below normal and dry years (about 3 to 5 percent of months outside the range). The impact is much greater during critical years, when about 30 percent of months are anticipated to be outside the aforementioned water temperature range. Although not specifically developed to meet the biological needs of CV spring-run Chinook salmon, depending on forecasted spring and fall storage metrics, the SR winter-run Chinook salmon objectives in the Shasta Framework will provide water temperatures at or downstream from the CCR gauge through October 31, or at the CCR gauge, or at some point upstream of the CCR gauge. After October 31, temperatures would likely increase to levels that reduce egg survival depending on the remaining cold water storage in Shasta Reservoir and the influence of ambient air temperatures.

On Clear Creek, water temperature management will provide suitable rearing habitat in all but the lowest section of Clear Creek, where water temperatures are expected to be warm and suboptimal for rearing and growth in the summer months. The proposed action will increase the summer temperature objective from 60°F to 61°F, but this is expected to have a negligible impact on migrating and rearing adults. Reducing instream flows down to 100 cfs in July would likely create a passage barrier at the confluence for late-arriving adults, resulting in increased rates of pre-spawning mortality for those individuals. The proposed action extends the 56°F temperature requirement to November 15. This action will improve water temperature conditions when fry are beginning to emerge, and a large proportion of out-migrating fry would experience higher flows, greater available habitat, and an increase in food availability during November to March.

On the Stanislaus River, the proposed action introduces stressors and degrades aquatic habitat conditions that affect the rearing success of yearlings. On the Stanislaus River, CV spring-run Chinook salmon would experience adverse temperature conditions for incubating eggs from August through February that reduce survival and production. During spring months, CV spring-run Chinook salmon can be affected by temperature and flow conditions that affect adult upstream migration and yearling rearing.

9.3.2.2. Pulse Flows

Reclamation is proposing to implement seasonal pulse flows on the Sacramento, American, and Stanislaus rivers and on Clear Creek. The purposes of the pulse flows differ by watershed but all have broad goals to improve habitat conditions and survival. The decisions around when and

how to implement the pulse flows will be carried out through the collaborative decision-making process as part of Governance. Central Valley spring-run Chinook salmon are no longer known to spawn in the American River, and pulse flows from this tributary are not expected to directly influence CV spring-run Chinook salmon survival. Still, there could be some beneficial effects of an American River pulse flow to non-natal rearing fish and fish in the Sacramento River migrating downstream past the confluence of the American River.

Reclamation's proposal to store cold water in reservoirs by capturing and storing inflow impairs the frequency and magnitude of high-flow events during winter and spring months, which can affect channel morphology and the quality and quantity of spawning and rearing habitat downstream. Pulse flows are a mechanism used to mitigate these impacts by creating seasonal conditions that improve channel morphology, create adult attraction flows, and improve juvenile rearing conditions and out-migration success.

On the mainstem Sacramento River, pulse flows are proposed during late winter or spring months when juvenile CV spring-run Chinook salmon are present and migrating downstream. The pulse flows will be designed through the SRG and the SHOT to mimic natural spring flows, and are intended to be timed to coincide with pulse flows from other Sacramento River tributaries.

The effects analysis in this opinion summarized that existing modeling shows that under the obligated releases scenario, the average mean annual survival ranges from approximately 6 to 24 percent, and under current operations, the range is approximately 6 to 25 percent. With the pulse flow action and other storage actions that could increase spill from Shasta, average annual survival increases to 11 to 26 percent, with the biggest increase being in critical years.

On Clear Creek, spring pulse flows are proposed to attract adult CV spring-run Chinook salmon to holding habitats in the upper sections of the watershed below Whiskeytown Dam. The effects analysis in this opinion discussed that pulse flows are expected to benefit a large number of adults and increase returns by encouraging movement to upstream reaches, resulting in a larger spawning population and increased genetic diversity in Clear Creek.

On the Stanislaus River, Reclamation proposed three types of pulse flows: fall pulse flows, winter instability flows, and spring pulse flows. The fall pulse flow(s) action is intended to improve instream flow conditions on the Stanislaus River, providing an attraction cue for adult CCV steelhead and increasing access to spawning habitat. This flow volume would occur in October or November, so its influence on CV spring-run Chinook salmon would be negligible. The winter instability flows will improve Stanislaus River conditions related to out-migration cues and juvenile-rearing habitat access. The spring pulse flows are intended to recreate some of the variability in the otherwise regulated and stable flows associated with seasonal operations. This element of the proposed action would improve migration conditions for juvenile salmonids migrating in the March to June timeframe improving survival.

NMFS expects that, to the degree sufficient storage is available to support pulse flows, the actions will address important threats, described in the recovery plan, for at least three of the four diversity groups of CV spring-run Chinook salmon by temporarily improving the quality of juvenile migration habitat in the mainstem Sacramento River. There may also be some benefits to CV spring-run Chinook salmon in the Southern Sierra Nevada Diversity group. We expect that seasonal pulse flow will have beneficial outcomes for the survival of individuals, but that the overall survival rates in dry years will still be lower than in other major western rivers. The

influence of pulse flows on the abundance and productivity of populations in the Northwestern California, Northern Sierra Nevada, Southern Sierra, and Basalt and Porous Lava diversity groups will be positive but is not quantifiable until we can better connect these survival gains in the life cycle model that will be developed through the proposed action.

9.3.2.3. Shasta Refill and Redd Maintenance

An important goal of refill and redd maintenance is to stabilize fall flows and avoid flow fluctuations that dewater redds and strand juveniles. Despite careful management through SRG and SHOT coordination, the implementation of this action will result in the stranding and death of a small proportion of CV spring-run Chinook salmon young-of-year and yearlings, particularly in below-normal and critical years. Modeling shows that the rate of stranding is slightly lower than under current operations. The proposed action has a coordination mechanism that is expected to further reduce the frequency of exposure over current operations because ramping rates will be managed through the SRG and the SHOT to minimize the magnitude of the effect on individuals.

9.3.2.4. Operation of the Delta Cross Channel Gates

As described for SR winter-run Chinook salmon, another effect of the proposed fall and winter flow reductions to refill the cold water pool in Lake Shasta would be that Reclamation opens the Delta Cross Channel gates more frequently during October and November than under current operations. Because the yearling Chinook migration is stimulated by precipitation in the upper basin, these fish enter the Delta during October through January-February. Juveniles reaching the Delta before December 1 (and during December and January when there are water quality issues) would be likely to encounter open gates, resulting in entrainment into the central Delta. Reclamation will, therefore, continue to use real-time monitoring to decide when enough fish are present to close the gates. Closing the gate is expected to limit entrainment into the Delta Cross Channel and the interior Delta for Northwestern California, Northern Sierra Nevada, and Basalt and Porous Lava diversity groups.

9.3.2.5. Old and Middle River Management and Entrainment and Loss at the Delta Export Facilities

Pumping water from the South Delta export facilities is another major component of the proposed action that would affect CV spring-run Chinook salmon. OMR flow management is used to reduce entrainment of fish, including CV spring-run Chinook salmon into the southern Delta and loss of fish at the export facilities. OMR management includes multiple action components that target different seasons and species. The action components developed for salmon and steelhead include the following:

- **Start of OMR Management:** The OMR management season begins either on December 1 or December 20, depending on certain smelt protection actions being triggered. Once the OMR management season starts, the OMR index, on a 14-day running average, will be no more negative than -5,000 cfs until the end of the OMR season.
- **Spring-Run Chinook Salmon and Surrogate Thresholds:** This action component would restrict exports based on the presence of hatchery surrogates in the salvage facilities. The approach is intended to more closely represent out-migration patterns and timing of natural CV spring-run Chinook salmon.

- **Storm Flex:** This action could potentially offramp the -5,000 cfs to be no more negative than -6,250 cfs prior to the last day of February.
- **End of OMR Management Season:** OMR management season concludes when on June 30 or when water temperatures at Mossdale and Prisoner's Point exceed 71.96°F for 7 non-consecutive days; whichever happens first.

Several of the action components described above will, indirectly, add new protections for CV spring-run Chinook salmon; the weekly distributed loss thresholds, while not specifically targeting CV spring-run Chinook salmon, would still provide some indirect protections; the modified approach to surrogate releases, which adds new release sites that will better approximate the distribution of natural CV spring-run Chinook salmon populations; the use of genetic confirmation to initiate action triggers; and the addition of a new temperature compliance point which will provide more conservative off-ramping to end the season.

The zone of influence for the effects of this element of the proposed action is concentrated in the South Delta, where populations of the Southern Sierra Nevada diversity group would have the greatest exposure. Populations entering the Delta via the Sacramento River are less exposed to these effects as the extent of hydrodynamic influence of Delta export operations diminishes with distance from the export facilities. Changes to through-Delta survival provide surrogates for the proportional effects of this element of the proposed action.

Central Valley spring-run Chinook salmon originating in the Sacramento River watershed from three diversity groups will be routed into the interior Delta at a rate of 15 to 20 percent. Those individuals would experience the interior Delta conditions affecting migration timing, and a fraction of which end up in salvage at the South Delta export facilities. Phenotypic CV spring-run Chinook salmon originating in the San Joaquin tributaries, including the SJRRP population, will be routed into the Old River at a rate of about 50 to 65 percent, depending on hydrology, the majority of whom are entrained at the export facilities. Those individuals would experience the interior Delta conditions affecting migration timing, and a fraction are expected to enter the zone of influence and possibly be salvaged at the South Delta export facilities. This opinion looks at through-Delta survival as a surrogate for the proportional effects of this element of the proposed action.

In terms of effects caused by the proposed action, this opinion first considers South Delta export operations and the export mediated OMR management on CV spring-run Chinook salmon by evaluating the effects of the proposed action in the context of the obligated release scenarios and current operations. The context of obligated release scenarios and the proposed action effects are important because this isolates Reclamation and DWR's modeled discretionary effect on through-Delta survival. The context of current operations and the proposed action is important for understanding how the proposed actions impacts are added to the environmental baseline.

The detailed effects of South Delta export discretionary operations and OMR management are discussed in the Bay-Delta Division effects analysis section of this opinion. The zone of influence for the effects of this element of the proposed action is concentrated in the South Delta, where populations of the Southern Sierra Nevada diversity group would have the greatest exposure. Populations entering the Delta via the Sacramento River are less exposed to these effects as the extent of hydrodynamic influence of Delta export operations diminishes with distance from the export facilities. Changes to through-Delta survival provide surrogates for the proportional effects of this element of the proposed action.

Under current operations, salvage ranges from 337 LAD spring-run Chinook salmon in critical years to 44,974 fish in wet years, while under the proposed action, the range is 345 LAD spring-run Chinook salmon to 63,773 fish. It is important to note that this should be considered in the context that a majority of these fish are likely to be fall-run Chinook salmon based on their size. Use of genetic identification, as included in the proposed action, will result in substantially lower salvaged fish identified as CV spring-run Chinook salmon.

In the context of through-Delta survival under current operations and the proposed action, through-Delta survival ranges from no difference in survival for above normal, below normal, dry, and wet water years to an increase in survival under the proposed action of 1 percent in critical water years.

Under the proposed action, OMR management is intended to provide similar types of protection but with more spatially resolved tracking (weekly loss thresholds rather than just seasonal), which is expected to result in fewer real-time OMR restrictions but should prevent disproportional losses of individual fish.

9.3.2.6. Spring Outflow

This element of the proposed action is specific to the proposed pre-adoption period of the Delta component of the VAs, which is a 2-year volumetric export reduction action but qualitatively considers DWR's proposal to implement export reductions based on San Joaquin River flows measured at Vernalis until the post-adoption period of the Delta component of the VAs. If the SWRCB approves VAs, the framework-level programmatic section of this opinion describes how they may be implemented. Because the zone of influence for the effects of this element of the proposed action is centered in the South Delta, populations of the Southern Sierra Nevada diversity group (e.g., CV spring-run Chinook salmon from the San Joaquin River) would have the greatest exposure. Populations entering the Delta via the Sacramento River, such as CV spring-run Chinook salmon from Clear Creek, would be less exposed to the effects of this element.

Central Valley spring-run Chinook salmon potentially exposed to this proposed action component include the 12 natural populations originating in the Sacramento River watershed, the phenotypic CV spring-run Chinook salmon originating in the San Joaquin tributaries and the SJRRP population, collectively comprising four diversity groups. There is the potential for 100 percent of juvenile CV spring-run Chinook salmon originating from the San Joaquin River or its tributaries, in dry to above normal water year types (56 percent of years), to be exposed to the improved migratory and rearing conditions in the interior Delta leading to an increase in productivity for those populations. Likewise, Sacramento River watershed-origin CV spring-run Chinook salmon whose migration route includes Georgiana Slough would be exposed to improved migratory conditions and survival in dry to above normal water year types. The Spring Outflow action contributes to a 0.6 to 46.2-percent decrease in modeled salvage at the Delta export facilities. These reduced salvage conditions are expected for the first 2 years of implementation. Some level of these benefits will occur as a result of DWR's commitment to manage spring outflows until VAs are in place. Reclamation may continue this pre-adoption action for longer than 2 years if substantial progress is being made to approve VAs, but they are not yet incorporated in the SWRCB's Water Quality Control Plan.

9.3.2.7. Governance and Adaptive Management

The Governance element of the proposed action describes the proposed engagement of participating state and federal agencies, interested parties, and the public and how they will work together during implementation. Governance establishes the teams and principles that are subject to ongoing collaborative implementation and decision-making and identifies the processes for working together and for elevating and resolving matters when there is a lack of consensus. For such a large and complicated project, Governance is essential for ensuring implementation is carried out as described in the proposed action, including the complicated interface between real-time operations and the ongoing technical and management discussions that inform operations and species protections, and that it remains within the bounds of the analysis in this opinion.

The proposed action also includes an AMP as a structured, iterative process for decision-making when confronted with uncertainty. Adaptive management emphasizes learning through management where knowledge is incomplete and provides a process for building knowledge through monitoring and science, reducing uncertainty, and improving management over time in a goal-oriented and structured way. The AMP and related special studies include over 20 actions. While they may not individually or collectively change the impacts of project-related effects on CV spring-run Chinook salmon, they are expected to improve management and inform actions that affect species risk.

9.3.2.8. Life Cycle Modeling

Life cycle model results were considered for the proposed action, as well as the current operations scenario, which is a representation of the past discretionary and non-discretionary effects of project operations. The life cycle modeling also includes an analysis of the obligated release scenario, which only focuses on past and future non-discretionary effects.

Based on these modeled results, the predicted total and natural-origin-only CV spring-run Chinook salmon spawner abundances for CV spring-run Chinook salmon in the Upper Sacramento River and Clear Creek fluctuated between 1980 and 1999, with a generally increasing trend in the Upper Sacramento River. The combined populations in the Upper Sacramento River and Clear Creek reached a low in the early 1980s, peaked in 1988, decreased steadily until 1990, and then trended upward until 1999 with slight declines in the following years.

9.3.2.9. Programmatic Actions

The opinion includes certain action components that were analyzed as framework-level programmatic actions for the development of future actions that may be authorized, funded, or carried out at a later time, and any take of a listed species would not occur unless and until those future actions are authorized, funded, or carried out and subject to further ESA section 7 consultation. We analyzed the effects of those actions qualitatively to understand how they might be carried forward in the context of water operations. The following framework programmatic actions are considered in this opinion:

- The Sites Reservoir Project: Adverse and beneficial effects to listed species and designated critical habitat. A broad suite of potential effects to individuals and PBFs of designated critical habitat are proposed to be minimized or avoided through established guiding principles, best management practices, adaptive management strategies, and monitoring and compensatory mitigation strategies. Project components include bypass

and pulse flow criteria, monitor and mitigate the effects of diversions, habitat restoration, and use of the best available science to develop and implement operations plans.

- The Delta Conveyance Project: Adverse and beneficial effects to listed species and designated critical habitat. A broad suite of potential effects to individuals and PBFs of designated critical habitat are proposed to be minimized or avoided through established guiding principles, best management practices, adaptive management strategies, and monitoring and compensatory mitigation strategies. Project components include bypass and pulse flow criteria, monitor and mitigate the effects of diversions, habitat restoration, and use of the best available science to develop and implement operations plans.
- Spring Outflow - Post-Adoption of VAs: This action is expected to result in improved flow conditions and reduced entrainment for listed species in the Delta during April and May and improved survival over baseline for rearing and migration. These responses are consistent with the objectives of the long-term operations of the CVP and SWP to implement actions that reduce entrainment and improve survival through the Delta. These responses would mostly affect juvenile fish in particular, as they are most susceptible to entrainment and flow-related survival. There may also be some responses to juvenile rearing and survival during spring months on the Sacramento and American rivers during certain water year types. Risks to listed species are low.
- Drought Response (i.e., Drought Toolkit): The Drought Response action includes components designed to avoid or mitigate the effects of drought. A drought planning team will evaluate the need for drought actions annually and propose them on a case-by-case basis. Given the framework-level programmatic nature of this action, it is possible to estimate the specific impacts but the overall objective is to consider and implement actions that avoid or mitigate drought-related consequences to listed species and their critical habitat.
- Monitoring: Many ongoing monitoring programs that inform operational actions and effects are currently under existing and separate ESA section 7 consultations and section 10(a)(1)(A) permits and considered in the Environmental Baseline section of this opinion. Potential future changes to monitoring programs associated with the operation of the CVP and SWP will be addressed in separate ESA section 7 consultations that are tiered to the consultation. Subsequent changes to existing monitoring programs would be coordinated and included in future consultations of the LTO of the CVP and SWP to allow for a more uniform analysis and improved accounting of incidental take coverage associated with the operation of the CVP and SWP.
- Tidal Habitat Restoration: Tidal habitat restoration will result in near-term impacts to aquatic and riparian habitat leading to lethal and sublethal impacts to listed species, but the risks to individuals will be avoided, minimized and mitigated through long-established best management practices. Post-construction habitat conditions will benefit the growth and survival of listed species and improve the conservation value of critical habitat.
- Adaptive Management and Special Studies: The Adaptive Management Program will utilize decision support tools such as structured decision-making to improve future management decisions to improve the operations of the CVP and SWP for project purposes. Most of the actions will improve the are intended to improve the capacity and precision of the projects to protect listed species.

9.3.3. Climate Change Considerations

Future projections over the duration of the proposed action (i.e., through 2030), considering climate change, exacerbate some of the proposed action risks to CV spring-run Chinook salmon. For example, climate change is expected to further degrade the suitability of habitats in the Central Valley through increased temperatures, increased frequency of drought, increased frequency of flood flows, and overall drier conditions.

As previously described in this opinion, adult CV spring-run Chinook salmon key on snowmelt runoff to access their higher elevation holding and spawning habitat. Thus, the shift from later runoff from snowmelt to earlier runoff from rain could disrupt cues for upstream migration. Adults would arrive in spawning areas earlier and be more likely to hold in unsuitable conditions. Also, juveniles emigrate during spring periods that often coincide with similar runoff events. Reclamation's proposed Clear Creek Pulse Flow Action is designed to manage the timing of spring runoff to improve the timing of both the upstream and downstream migrations.

The proposed action includes measures to address climate change. For CV spring-run Chinook salmon, these include the application of climate change scenarios in the CalSim modeling, the continued use of conservative forecasts and the collaborative process of SRG and SHOT coordination, especially regarding timing and shaping of spring flows, and the use of Drought Planning and the Drought Toolkit.

The DRY Team will convene on an annual basis, centered around the start of each water year, to assess the need for drought response actions, which would be elevated to WOMT in water years where hydrology or water storage (e.g., drought) present challenging water management decisions that cannot be fully addressed by annual operations planning. In those years the DRY Team will coordinate and review potential Drought Toolkit actions meant to avoid or mitigate drought impacts. As a primary tool of the DRY Team, and as a resource for managers (e.g., SHOT and WOMT), the Drought Toolkit is an approach by which the DRY Team may coordinate with the SHOT and WOMT to recommend and evaluate the implementation of drought actions. At the time of this consultation, there are 25 drought response actions that are included in the Drought Toolkit, however, more may be added as new approaches and actions are developed to address future drought conditions. While these are not necessarily prescriptive actions implemented based on triggers, they are expected to play a role in minimizing impacts to CV spring-run Chinook salmon during drought periods.

9.3.4. Risk to the Central Valley Spring-Run Chinook Salmon Evolutionarily Significant Unit

The CV spring-run Chinook salmon listed ESU boundary is currently delineated as all naturally spawned CV spring-run Chinook salmon originating from the Sacramento River and its tributaries downstream of barrier dams. The listed ESU boundary does not include the San Joaquin River or its tributaries because CV spring-run Chinook salmon were considered extirpated from the basin at the time of listing. However, the San Joaquin now includes an NEP in the SJRRP area, and CV spring-run Chinook salmon are periodically observed in the Stanislaus, Tuolumne, and Merced rivers. There is only one remaining Core 1 population and it is in the Sacramento River basin.

The proposed action includes many components that have been developed through iterative, collaborative, and scientific processes over the past 15 years and through the development of the

proposed action that is subject to this consultation. These include refined approaches for managing temperatures and storage at Shasta; improved processes for technical, scientific and policy coordination that should provide more responsive decision-making when Shasta or Delta conditions are stressed; refined approaches for managing OMR with weekly loss triggers that should allow for more careful management of loss during periods of periodically high salvage; and using genetics to more precisely inform CV spring-run Chinook salmon decision-making.

Regardless of the iterative improvements, the proposed action will continue to result in ongoing adverse effects to CV spring-run Chinook salmon. Here, we discuss them in the context of the Central Valley Diversity Groups:

9.3.4.1. Northwestern California

There are presently three CV spring-run Chinook salmon populations in this diversity group, with one Core 1 population in Clear Creek, a Core 2 population in Beegum Creek, and a Core 3 population in Thomes Creek.

Habitat in Clear Creek below Whiskeytown Dam is believed to be historically unsuitable for CV spring-run Chinook salmon holding and spawning and rearing, and current habitat on Clear Creek must be maintained by releases from Whiskeytown Dam and any level of degradation to the functioning of that habitat further limits its conservation value. Reclamation proposes to maintain suitable minimum base flow and temperature management in Clear Creek, and includes channel maintenance and spring attraction pulse flows. Minimum instream base flows are expected to continue to inhibit habitat-forming processes and restrict habitat access, although continued exposure to unsuitably warm temperatures is likely much less frequent than what would occur without ongoing temperature management operations. Under the proposed action, spring attraction and channel maintenance pulse flows are expected to improve spawning habitat quality and quantity by mobilizing and dispersing gravel and reducing fine sediment, and provide improvements to juvenile rearing habitat, and the fresh water migratory corridor compared to current conditions, although pulse flows also have the potential to strand a small proportion of juveniles and dewater redds.

All CV spring-run populations in the ESU, with the exception of Clear Creek and Antelope Creek (in the Northern Sierra Diversity Group), have been exhibiting declines in abundance over time. The CV spring-run Chinook salmon population on Clear Creek is an exception where significant progress continues towards achieving presence of a population.

9.3.4.2. Basalt and Porous Lava

This diversity group historically included spawning populations in four different river systems and are now present in two, including the mainstem Sacramento River below Keswick, which is a Core 2 population at an unknown risk of extinction and in Battle Creek, which is a Core 1 population at moderate risk of extinction. Central Valley spring-run Chinook salmon on the mainstem Sacramento River are not thought to be numerous. Yet, in some years, the majority of fish collected in the spring and summer months in the Keswick trap as adults are genetically assigned as non-winter-run Chinook salmon. Based on when they are sampled, they are likely CV spring-run Chinook salmon. Consideration should be given to the use of genetics to improve our assessments of CV spring-run Chinook salmon in the Sacramento River.

Competition and hybridization with fall-run Chinook salmon, exacerbated by changes in river conditions due to Shasta and Keswick dams, have likely reduced the genetic integrity and reproductive success of natural-origin CV spring-run Chinook salmon (National Marine Fisheries Service 2014b). Current monitoring efforts struggle to differentiate between CV spring-run and fall-run Chinook salmon, resulting in uncertainty regarding the actual abundance of natural-origin CV spring-run Chinook salmon on the mainstem Sacramento River. The presence of hatchery-origin CV spring-run Chinook salmon further complicates the assessment of natural-origin fish. However, genetic analysis of hatchery fish and the observation of straying individuals indicate that some level of natural spawning likely still occurs in the Sacramento River (Killam 2022).

9.3.4.3. Northern Sierra Diversity Group

This diversity group contains the only remaining Core 1 populations of CV spring-run Chinook salmon in the ESU, including Mill, Deer, and Butte creeks populations, which have seen significant declines in recent years. The Antelope Creek population, which is considered a Core 2 population, has shown some minor gains in abundance in recent, but not all, years.

The proposed action will affect these populations through winter and spring baseflow releases and pulse flow releases from Shasta and Whiskeytown reservoirs. Reclamation's in-river survival modeling shows that managed pulse flows from Shasta will result in small increases in overall survival. Preliminary results of recent pulse flow studies show that juvenile fish survival was 400 to 600 percent higher than control fish that did not experience pulse flows (Notch 2024). This insightful information will be used to adaptively manage future pulse flows under the proposed action.

9.3.4.4. Southern Sierra Nevada

This diversity group historically included spawning populations in four different river systems, but the fish are now known to be occasionally present in three, the Stanislaus, Tuolumne, and Merced rivers. These individuals or populations would be exposed to and affected by operations from, and including, the Stanislaus River, downstream through the Delta.

At the time of listing, CV spring-run Chinook salmon were considered extirpated in the San Joaquin basin. Recently, juvenile and adult fin clips from Chinook salmon collected in 2021 and 2022 in the Stanislaus, Tuolumne, and Merced rivers were determined to have some CV spring-run Chinook salmon ancestry in all three rivers (Clemento and Garza 2023). The confirmed presence of CV spring-run Chinook salmon homozygote and spring/fall-run heterozygote juveniles confirms that adults with CV spring-run Chinook salmon ancestry successfully spawned in these rivers and strongly suggests that CV spring-run Chinook salmon were the parents of some of these individuals (Clemento and Garza 2023). As such, this new research contributes to a growing understanding that suggests passive reestablishment of CV spring-run Chinook salmon throughout the San Joaquin River basin (Gutierrez et al. 2024).

At the time of this consultation, the status of CV spring-run Chinook salmon in the Stanislaus River is still uncertain and the proposed action effects on the Stanislaus River population are not expected to reduce the overall viability of the ESU, however, there is value in continuing to monitor and improve our scientific understanding of these fish.

9.3.4.5. Risk to Central Valley Spring-Run Chinook Salmon and the Evolutionarily Significant Unit Level

Both individually and collectively, CV spring-run Chinook salmon populations and individuals in Clear Creek, the Sacramento River, and Stanislaus River, do not strongly influence the overall viability of the ESU, which is driven by the Core 1 populations in Mill, Deer, and Butte creeks. This is not to suggest that they are not important, because even small populations play a role in the ESU's viability, especially when overall abundance is low, such as under present circumstances. More significantly, the CV spring-run Chinook salmon ESU is influenced by factors in the main stem of the Sacramento River and the Delta.

The proposed action includes many components that have been developed through iterative, collaborative and scientific processes over the past 15 years and through the development of the proposed action that is subject to this consultation. Important refinements for CV spring-run Chinook salmon include improved certainty that the spring pulse flow will be implemented on the Sacramento River, which is expected to slightly improve juvenile survival; new surrogate methods for OMR management where releases are distributed more diversely across watersheds that serve as a better proxy for natural fish than the Coleman National Fish Hatchery releases have been used over the past 15 years; and a structured, time-bound commitment to develop a CV spring-run Chinook salmon JPE and new loss thresholds that will be tailored to population size. There will also be improved technical, scientific, and policy coordination, which should provide for more responsive decision-making when Shasta or Delta conditions are stressed, and refined approaches for managing OMR with weekly loss triggers that should allow for more careful management of loss during periods of periodically high salvage.

Regardless of the iterative improvements, the proposed action will continue to result in ongoing adverse effects to CV spring-run Chinook salmon. The improved processes for managing loss and OMR, combined with DWR's non-physical barrier at the head of Georgiana Slough, which appears to be very effective at reducing routing at this junction, and both Reclamation's 2-year commitment to reduce exports for increasing spring outflow and DWR's more comprehensive approach for tying outflow volumes to Vernalis flow, are expected to increase through-Delta survival over current conditions.

Seasonal pulse flows will have beneficial outcomes for the survival of individuals, but overall survival rates remain very low, ranging from approximately 11 percent in critical years to 26 percent in wet years. Overall survival rates in the Sacramento River are much lower than in other West Coast salmon rivers such as the Columbia and Yakima rivers, where juvenile Chinook salmon survival in long river reaches is closer to 27 percent. Many factors are likely contributing to lower survival rates. Flows in the Sacramento River are highly regulated and peak discharge is typically very reduced in spring months. Modeling for the effects analysis suggests this is largely attributed to non-discretionary operations. Other factors, such as habitat conditions and the quality of rearing habitat, also reduce juvenile survival rates.

Because of the overall low survival rates, the influence of pulse flows on the abundance and productivity of populations in the Northwestern California, Northern Sierra Nevada, Southern Sierra, and Basalt and Porous Lava diversity groups is unknown. Based on the significantly impaired status of the CV spring-run Chinook salmon ESU, it is unlikely to have a significant influence on improving the status of the ESU.

The proposed action does include measures to address climate change. For CV spring-run Chinook salmon, these include the application of climate change scenarios in the CalSim modeling, the continued use of conservative forecasts and the collaborative process of SRG and SHOT coordination, especially regarding timing and shaping of spring flows, and the use of Drought Planning and the Drought Toolkit.

As described in the Analytical Approach of this opinion, the risk to the CV spring-run Chinook salmon ESU posed by the proposed action is evaluated in the aggregate context of the effects of the species' status, the environmental baseline, cumulative effects, and effects from interrelated and independent actions. In total, NMFS expects that despite ongoing adverse effects of the CVP and SWP on individuals and their respective populations, and the continued and significant adverse effects that are part of the environmental baseline, such as the loss of historical habitat related to the physical presence of Keswick and Shasta dams, the proposed action includes measures intended to maintain and, in some cases, improve the survival of individuals.

The assessment of risk also considers VSP parameters as summarized in Table 174.

Table 174. Summary of Viable Salmonid Population (VSP) parameters considered in the analysis of effects.

VSP Parameter	Proposed Action Considerations	VSP Considerations
Abundance	Temperature and flow management in Clear Creek is tailored to support the Central Valley (CV) spring-run Chinook salmon population. Pulse flows are implemented specifically to attract adults into this Central Valley Project tributary. Pulse flows on the Sacramento River are implemented to support the survival of out-migrating juvenile fish from the Upper Sacramento River and spring-run tributaries, including Clear, Mill, and Deer creeks. Delta Operations actions are increasingly focused on abundance metrics and Juvenile Production Estimate (JPE)-based OMR (Old and Middle rivers) triggers and actions will emerge through the adaptive management program. Risk assessments consider seasonal abundance and exposure in the Delta.	Clear Creek supports an important Core 2 population that has shown resilience during drought conditions and is an important population for supporting the abundance metric for the evolutionarily significant unit (ESU). The Sacramento River supports a Core 2 population of CV spring-run Chinook salmon, but there remains uncertainty regarding this population's contribution to the ESU's viability.

VSP Parameter	Proposed Action Considerations	VSP Considerations
Productivity	Seasonal pulse flows Delta Operations: JPE-based OMR triggers and actions, and risk assessments	An important objective of seasonal pulse flows is to improve juvenile survival and production. A JPE is proposed for CV spring-run Chinook salmon for the purposes of linking Delta export losses to population and production.
Diversity and Spatial Structure	Seasonal pulse flows, hatchery release surrogates, and OMR actions	Seasonal pulse flows contribute to spatial structure parameters in a few different ways. First pulse flows on Clear Creek are intended to attract adult CV spring-run Chinook salmon upstream from the Sacramento River into alternative holding and spawning habitat. This increases the spatial diversity of habitats utilized by adults and spreads the risk by helping to distribute adults outside of the Upper Sacramento River.
Habitat Capacity and Diversity	Clear Creek temperature and instream flow management Seasonal pulse flows on the Sacramento River	Water management actions on Clear Creek are largely responsible for the occurrence of the existing population of CV spring-run Chinook salmon in this stream.

NMFS has finalized recovery planning for the CV spring-run Chinook salmon ESU (National Marine Fisheries Service 2014d). Several elements of the proposed action align with or directly implement recovery actions identified in the recovery plan. The proposed action also does not impede implementation of other key elements of the recovery plan, such as improving water conservation across California, incorporating ecosystem restoration in flood control planning, and improving salmon harvest monitoring and management. Implementation of the proposed action is, therefore, not creating conditions that would preclude recovery of CV spring-run Chinook salmon in the future. Should VAs be approved by the SWRCB, this opinion may provide an efficient regulatory mechanism for permitting their implementation, as described in the proposed action.

Considering its current rangewide status, the environmental baseline within the action area, the effects of the proposed action, the effects of other activities, and cumulative effects, NMFS concludes that the proposed action is not likely to appreciably reduce the likelihood of both the survival and recovery of the CV spring-run Chinook salmon ESU.

9.4. Central Valley Spring-Run Chinook Salmon Effects on Designated Critical Habitat

9.4.1. Summary of the Status of Designated Critical Habitat

As described in the Status of the Species and Critical Habitat sections, the geographical range of designated critical habitat for CV spring-run Chinook salmon includes stream reaches of the Feather, Yuba, and American rivers; Big Chico, Butte, Deer, Mill, Battle, Antelope, and Clear creeks; and the Sacramento River downstream to the Delta, as well as portions of the northern Delta. Within the range of the CV spring-run Chinook salmon ESU, the PBFs of the designated critical habitat that are considered vital for CV spring-run Chinook salmon include freshwater spawning sites, freshwater rearing sites, water quantity and floodplain connectivity, water quality and forage, natural cover, freshwater migration corridors, and estuarine areas.

As generally described in the Status of the Species and Critical Habitat sections, the status of critical habitat in each of these PBFs is considered to be highly degraded. In general, stressors to CV spring-run Chinook salmon critical habitat PBFs include water diversions and water management, dams and other structures, loss of floodplain connectivity, loss of natural riverine function, bank protection; dredging, sediment disposal, gravel mining, invasive aquatic organisms, and agricultural, urban, and industrial land use (McEwan 2001). The quality of spawning habitat used by CV spring-run Chinook salmon in the mainstem Sacramento River is diminished when fall-run Chinook salmon, which commence spawning slightly later in the season than CV spring-run Chinook salmon, arrive at the spawning grounds, move gravels around for redd construction, and physically disturb CV spring-run Chinook salmon redds during that process. Spawning and egg incubation habitat for CV spring-run Chinook salmon in the mainstem Sacramento River is often negatively affected by operations of the CVP through warm water releases from Shasta Reservoir. Freshwater rearing and migration habitats have been degraded, which delays upstream migration, reduces the availability of quality rearing habitat, and creates improved feeding opportunities for predators such as pikeminnow and striped bass. Additional negative effects to rearing and migration habitats within the Sacramento River include loss of natural river function and floodplain connectivity through flow regulation, levee construction, direct loss of floodplain and riparian habitat, and effects to water quality associated with agricultural, urban, and industrial land use.

Based on the host of stressors to spawning, rearing, migratory, and estuarine habitats in the Central Valley, it is apparent that the current condition of CV spring-run Chinook salmon critical habitat is degraded.

9.4.2. Summary of Proposed Action Effects on Designated Critical Habitat by Division

Proposed action-related effects to CV spring-run Chinook salmon designated critical habitat are summarized below. Detailed descriptions regarding the effects of the proposed action on CV spring-run Chinook salmon designated critical habitat are presented in the Effects of the Action section.

9.4.2.1. Clear Creek

9.4.2.1.1. Status of Central Valley Spring-Run Chinook Salmon Critical Habitat in Clear Creek

The PBFs of CV spring-run Chinook salmon habitat in Clear Creek include freshwater spawning, rearing, and migration. Whiskeytown Dam, located at river mile 18.3 on Clear Creek, is an impassable barrier to adult anadromous salmonids and marks the upstream extent of potential CV spring-run Chinook salmon habitat. The McCormick-Saeltzer Dam blocked upstream migration of anadromous salmonids from 1903 until it was removed in the fall of 2000. Following its removal, approximately 12 miles of coldwater habitat upstream to Whiskeytown Dam became available. The construction of Whiskeytown Dam, gold mining, and significant gravel mining in the Clear Creek watershed has diminished the availability and recruitment of suitable spawning gravels. Channel restoration and gravel injection projects are being conducted to compensate for this loss of spawning gravel recruitment and suitable spawning habitat on Clear Creek.

9.4.2.1.2. Project Effects on Central Valley Spring-Run Critical Habitat in Clear Creek

The proposed action's seasonally variable instream flows would improve the channel complexity for rearing habitat PBFs during winter and spring, lead to increased growth, and provide refugia from predators. During the summer and fall, decreased flows would reduce the amount of available habitat. Water temperature management would provide suitable rearing habitat in all but the lowest section of Clear Creek, where water temperatures are expected to be warm and suboptimal for rearing and growth in the summer months, degrading the rearing habitat PBFs. Pulse flows are expected to improve spawning habitat quality to some extent compared to current conditions, although the magnitude and duration of flows would not be great enough to substantially improve the functioning of PBFs in this reach.

9.4.2.1.3. Assess Risk to Central Valley Spring-Run Chinook Salmon Critical Habitat in Clear Creek

Habitat in Clear Creek below Whiskeytown Dam is believed to be historically unsuitable for CV spring-run Chinook salmon spawning and rearing (Lindley et al. 2004). As a result, CV spring-run Chinook salmon habitat on Clear Creek must be maintained by releases from Whiskeytown Dam. The proposed action includes a seasonally variable hydrograph, with higher releases in the winter and lower releases in the summer, and also pulse flows for spring attraction and channel maintenance. The pulse flows are expected to improve spawning habitat quality and quantity by mobilizing and dispersing gravel and reducing fine sediment, and provide incremental improvements to juvenile rearing habitat and the freshwater migratory corridor. However, channel maintenance pulse flows would not provide the magnitude needed for channel shaping and floodplain inundation (3,000 to 6,000 cfs) because releases are limited by the outlet capacity at Whiskeytown Dam (currently 840 cfs). The pulse flow volume under the proposed action will be reduced to half (i.e., 5,000 acre-feet) in critical water year types.

9.4.2.2. Mainstem Sacramento River

9.4.2.2.1. Status of Central Valley Spring-Run Chinook Salmon Critical Habitat in the Mainstem Sacramento River

Negative effects to rearing and migration habitats within the Sacramento River include loss of natural river function and floodplain connectivity through levee construction, direct loss of floodplain and riparian habitat, and effects to water quality associated with agricultural, urban, and industrial land use.

9.4.2.2.2. Project Effects on Central Valley Spring-Run Chinook Salmon Critical Habitat in the Mainstem Sacramento River

The proposed action adversely affects critical habitat for CV spring-run Chinook salmon from the mainstem Sacramento River in several ways. As shown in Table 175, the proposed action produces stressors to CV spring-run Chinook salmon spawning, rearing, and migratory habitat in the mainstem Sacramento River.

Table 175. Effects of the proposed action on the physical and biological features of Central Valley spring-run Chinook salmon designated critical habitat in the Sacramento River.

Life Stage	Action Component	Location of Effect	Physical and Biological Features (PBFs) Affected	Response and Rationale of Effect
Spawning Adults, Incubation of Eggs, and Rearing for Fry	Fall and Winter Operations	From Keswick Dam to Bend Bridge	Freshwater Spawning Sites	The operations of Shasta and Keswick dams mobilize spawning gravel and the presence of the dam in the Environmental Baseline limits the recruitment of clean gravel for spawning substrate as they block the downstream transport of gravels to the accessible reach of the river.
Freshwater Rearing Habitat for Juveniles	Fall and Winter Operations	From Keswick Dam to the Delta	Freshwater Rearing Sites	Reduced flow variability decreases rearing habitat quantity and complexity.
Freshwater Migratory Corridor PBFs for Out-migrating Juveniles and Spawning Adults	Spring Operations	From Keswick Dam to the Delta	Freshwater Migration Corridors	Reduced flow variability reduces cues for juvenile emigration and adult migration and habitat during the spring.

9.4.2.2.3. Assess Risk to Central Valley Spring-Run Chinook Salmon Critical Habitat in the Mainstem Sacramento River

Habitat within the mainstem Sacramento River below Keswick Dam is believed to have been historically unsuitable for CV spring-run Chinook salmon spawning and rearing (Lindley et al. 2004). As a result, CV spring-run Chinook salmon habitat on the mainstem Sacramento River must be maintained by releases from Keswick Dam. The proposed action results in a reduction in the quantity or quality of freshwater spawning and rearing sites. In the freshwater migration corridor, seasonal operations reduce the suitability of rearing habitat in the middle Sacramento River. Migratory and rearing habitats in the middle Sacramento River are believed to be substantially degraded (National Marine Fisheries Service 2016a). This diminishes the ability of any CV spring-run Chinook salmon populations from the Sacramento Basin (e.g., mainstem Sacramento River and Clear Creek) to successfully rear in the Sacramento River or migrate to the Delta. Migratory and rearing PBFs of these habitats are not expected to change substantially under the proposed action.

9.4.2.3. Delta

The PBFs of critical habitat for CV spring-run Chinook salmon in the Delta include freshwater and estuarine rearing and migration. Estuarine habitats for CV spring-run Chinook salmon have been substantially degraded (e.g., Sommer et al. [2007]). Evidence of this includes the collapse of the pelagic community in the Delta and dramatic habitat changes related to water quality, toxic algae blooms (e.g., Microcystis), and invasive species (e.g., the aquatic macrophyte *Egeria densa*).

9.4.2.3.1. Project Effects on Central Valley Spring-Run Chinook Salmon Critical Habitat in the Delta

All CV spring-run Chinook salmon diversity groups must pass through the Delta during their migrations to and from the Pacific Ocean. The effects of the proposed action on designated critical habitat in the Delta are summarized in Table 176. Detailed descriptions regarding the exposure, response, and risk to CV spring-run Chinook salmon from these stressors are presented in the Effects of the Action section.

Table 176. Summary of probable change in physical or biological features of Central Valley spring-run Chinook salmon designated critical habitat in the Delta.

Action Component	Physical or Biological Feature Affected	Response
Water transfers	Freshwater rearing sites	(1) In-river flows that provide suitable water temperature conditions in the mainstem Sacramento River. (2) Flows that provide suitable dissolved oxygen conditions through improved mixing of water column and water surface-air interface. (3) Water quality sufficient to support primary and secondary productivity, benefitting forage base. (4) Insufficient conditions for successful holding and rearing for juveniles in the south Delta due to water transfers resulting in increased exports.

Action Component	Physical or Biological Feature Affected	Response
Water transfers	Freshwater migratory corridor	Enhanced flows from water transfers can benefit migratory habitat for juveniles migrating downstream by decreasing travel times, increasing the length of riverine reaches, and muting downstream tidal effects. Contribution of water transfers to increased exports hinder the ability for juveniles to successfully migrate through the South Delta.
North Bay Aqueduct/ Barker Slough Pumping Plant	Freshwater migratory corridor	Operations of North Bay Aqueduct/Barker Slough Pumping Plant alter flow patterns affecting the migratory corridor PBF thereby inhibiting the mobility of juvenile listed salmonids and reducing their survival.
Delta Cross Channel Gate Closures (and Maintenance and Repair)	Freshwater migratory corridor	(1) Access to the interior Delta through open Delta Cross Channel gates reduces the survival of migrating juveniles, reducing the value of the mainstem as a suitable migratory corridor. (2) Operations of the Delta Cross Channel gates can alter the extent of tidal influence in the river reaches downstream of the Delta Cross Channel location, delaying migration or re-routing juveniles into alternate migratory routes with lower survival. (3) Operations of the Delta Cross Channel gates reduces the upstream migratory function of the mainstem Sacramento River to adults. (4) Open Delta Cross Channel gates allow entrainment into habitat exposed to the influence of the SWP and CVP export actions and reduces migratory habitat function.
Delta Smelt Summer and Fall Habitat	Freshwater rearing sites	Release of additional water from upstream to augment Delta outflow will improve water quality and enhance forage prey populations that support juvenile salmonid development.
Delta Smelt Summer and Fall Habitat	Freshwater migratory corridor	Release of additional water from upstream to augment Delta outflow will improve water quality and conditions supporting the mobility and survival of adult and juvenile salmonids
Delta Smelt Summer and Fall Habitat	Estuarine areas	Release of upstream water will (1) enhance water quality, water quantity, and provide suitable salinity conditions supporting juvenile and adult salmonid physiological transitions; and (2) enhance forage prey that will support growth and maturation. Operations of the Suisun Marsh Salinity Control Gates will create temporary obstructions to free migration and potentially create predator habitat.

9.4.2.3.2. Assess Risk to Central Valley Spring-Run Chinook Salmon Critical Habitat in the Delta

Currently degraded estuarine habitat conditions that include altered hydrology in migration habitat and poor rearing habitats are expected to remain the same, with modest improvements or degradation under the proposed action. Tidal habitat restoration under the proposed action will likely improve some rearing and migratory habitat quality, but is unlikely to substantially minimize all of the negative effects of operations and barriers on habitat associated with outflow and water quality. Under current usage practices, human population growth will increase the demand on limited water supplies, potentially exacerbating negative effects on freshwater and estuarine rearing and migratory habitats within the domain of CV spring-run Chinook salmon.

9.4.3. Risk to Central Valley Spring-Run Chinook Salmon Critical Habitat at the Designation Level

Critical habitat for CV spring-Chinook salmon is highly degraded due to the effects of past and ongoing actions. Ongoing private, state, and federal actions and future non-federal actions are likely to continue to impair the function of PBFs and slow or limit the development of these features, although restoration actions will counteract these effects to some degree. Climate change is expected to further degrade the suitability of habitats in the Central Valley through increased temperatures, increased frequency of drought, increased frequency of flood flows, overall drier conditions, and altered estuarine habitats. Proposed water management actions are expected to reduce some of these impacts by increasing water storage that can be released during summer months.

Implementation of the proposed action is expected to negatively affect CV spring-run Chinook salmon critical habitat in several ways. The proposed action produces stressors to spawning, rearing, and migratory habitat PBFs in the Sacramento River from the Shasta cold water pool management action. Those stressors include exposure to warm water temperatures during egg incubation and juvenile rearing, Delta Cross Channel operations, and loss of natural river function and morphology affecting all habitat types and rearing habitat quantity and quality. During the proposed fall and winter refill and redd maintenance action, access to riparian habitat in the upper middle Sacramento River is expected to improve, which increases successful juvenile development and survival; however, decreased flows would limit downstream juvenile migration.

Water temperatures are also expected to exceed temperature objectives in Clear Creek during the summer and early fall months. These warmer temperatures are expected to further degrade the quality of rearing and spawning habitat PBFs for CV spring-run Chinook salmon.

Rearing and migratory habitat PBFs are expected to be degraded by Delta Cross Channel gate operations. Opening the radial gates allows access to the Delta interior through a manmade channel, which diminishes the functionality of the rearing and migratory quality of the mainstem Sacramento River from its original configuration. Without the Delta Cross Channel, there is no connection to the interior Delta at this location. Providing an artificial route into the Delta interior allows access to habitat that has reduced survival value compared to the mainstem Sacramento River channel. In contrast, the proposed extension of the water transfer window provides beneficial changes to designated critical habitat. The release of additional water for transfer from upstream sources has the potential to improve the flow volume in river channels feeding into the Delta over the “no” transfer conditions. Increased flows can create conditions that reduce travel times for downstream migrants, which improves migration success through reduced mortality. Furthermore, additional flow can increase the proportion of the river channels that are riverine in nature, compared to those with tidal oscillations that can reverse flows in the river channels. Recent studies (Perry et al. 2018) have shown that riverine reaches have higher survival potential than tidal reaches. Thus, increasing the proportion of river reaches with riverine characteristics in the Delta will enhance survival potential of emigrating CV spring-run Chinook salmon juveniles.

The proposed action is likely to affect key spawning reaches and a large portion of the migration and rearing habitat within designated critical habitat for CV spring-run Chinook salmon. Although the PBFs of critical habitat for CV spring-run Chinook salmon have been highly degraded, the proposed action will improve some past effects of the CVP and SWP. NMFS expects the proposed ongoing operation of the CVP and SWP will result in diminished function of PBFs related to spawning, rearing, and migration within designated critical habitat in the action area. However, on the whole, the function of PBFs of critical habitat will not be significantly reduced. The proposed action is, therefore, not likely to appreciably diminish the value of the critical habitat for the conservation of CV spring-run Chinook salmon.

9.5. California Central Valley Steelhead

9.5.1. Summary of the Environmental Baseline, Cumulative Effects, and Status of the Species

The status of CCV steelhead is described in detail in the Status of the Species section of this opinion; in the Environmental Baseline section, where the status is discussed in terms of the past and present impacts of all federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed federal projects in the action area that have already undergone formal or early ESA section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process; and in the Cumulative Effects section, that discusses the effects of future state or private activities, not involving federal activities, that are reasonably certain to occur within the action area of the federal action subject to consultation.

In this opinion, the effects of past CVP and SWP operations and existing structures are also part of the environmental baseline. Effects of those actions have been analyzed through past consultation and contributed to the current condition of the species and critical habitat in the action area. Other past, present, and ongoing impacts of human and natural factors (including proposed federal projects that have already undergone ESA section 7 consultation) contributing to the current condition of the species and critical habitat in the action area are also included in the environmental baseline.

CDFW issued a CESA ITP to DWR for the Long-term Operations of the SWP in the Delta in November, 2024 (California Department of Fish and Wildlife 2024c). Most of the actions covered in the CESA ITP are also included in this opinion because DWR is an applicant in the consultation. One action that is not part of Reclamation's proposed action is the Georgiana Slough Salmonid Migratory Barrier. Operation of the Georgiana Slough Salmonid Migratory Barrier is expected to provide a higher probability of survival for emigrating juvenile salmonids that encounter the Sacramento River-Georgiana Slough junction and reduce entrainment of emigrating juvenile salmonids into the central and south Delta and at the state and federal export facilities. The reduced routing effects of this action were not analyzed in the modeling for Reclamation's proposed action.

California Central Valley steelhead are exposed to numerous cumulative effects, such as unscreened water diversions, agricultural practices that impact water quality and riparian habitat, water contamination from municipal and agricultural sources, effects of urbanization, recreational and commercial fisheries, and other activities.

The DPS is currently represented by numerous small populations across all four diversity groups in the Central Valley. The construction and presence of dams blocks access to much of the historic habitat of CCV steelhead. There are approximately six Core 1, 16 Core 2, and four Core 3 populations and several candidate watersheds for reintroduction. Based upon the limited information available, the overall viability of the CCV steelhead DPS appears to be unchanged since the NMFS (2016b) 5-year review. However, the majority (11 of 16) of populations for which there are data are at a high risk of extinction based on abundance and/or hatchery influence, with no population considered to be at a low risk of extinction. The lack of improved natural production estimates, and low abundances coupled with a large hatchery influence are causes for continued concern (National Marine Fisheries Service 2023d).

As described previously in the opinion, CCV steelhead reproduce and rear in Clear Creek, the Sacramento, American, and Stanislaus rivers, and they rear and migrate through the Delta. This places them in four diversity groups, including the Northwestern Diversity Group (Clear Creek), the Basalt and Porous Lava Diversity Group (the Sacramento River), the Northern Sierra Diversity Group (the American River), and the Southern Sierra Diversity Group (the Stanislaus River).

9.5.2. Summary of the Proposed Action Effects to the Species

The effects analysis identified several proposed action components with stressors that have medium to high levels of severity resulting in a medium to high magnitude effect for CCV steelhead. Major effects to CCV steelhead from the proposed action are associated with water temperature management, pulse flows, ramping rates and seasonal flow variability, Delta Cross Channel Gate Operations and OMR Management and Entrainment, and Spring Outflow. Other important considerations are governance, adaptive management, and climate change. The likely effects on individuals and the viability of populations in the affected diversity groups are reviewed in the following sections. Table 177 illustrates the affected life stages, primary stressors/effect pathways, and relevant management actions by CVP and SWP division or waterbody.

Table 177. Affected life stages, primary stressors/effect pathways, and relevant management actions by Central Valley Project/State Water Project division or waterbody.

Division/Water body	Seasonal Operations Period	Affected Life Stage	Summary of Primary Stressors and Effects of the Proposed Action	Relevant Management Actions
Clear Creek	Summer Operations	Upstream Migration	Water temperature ● Temperatures create temporary migration barriers at confluence in July and August	Seasonal temperature objectives
Clear Creek	Summer Operations	Juvenile Rearing	Summer instream flows ● Summer flows may restrict the quantity and quality of rearing habitat	Instream Flow Objectives, Pulse flows

Division/Water body	Seasonal Operations Period	Affected Life Stage	Summary of Primary Stressors and Effects of the Proposed Action	Relevant Management Actions
Clear Creek	Summer Operations	Juvenile rearing	Water temperature ● Suboptimal temperature in lower 3 miles (>65°F)	Seasonal temperature objectives
Clear Creek	Summer Operations	Juvenile Rearing	Stranding ● Juvenile stranding as flows recede affects small number of individuals	Ramping rates
Clear Creek	Fall Operations	Egg incubation and emergence	Water temperature ● Suboptimal temperatures in critical years may cause egg mortality and reduce production	Seasonal temperature objectives, pulse flows, and minimum instream flows
Clear Creek	Spring Operations	Adult and Juvenile Migration	Instream Flows ● Pulse flows provide adult attraction into holding habitat and cue juvenile out-migration	Pulse flows
Sacramento River	Fall and Winter Operations	Adult spawning and egg incubation	Water temperature ● May exceed optimal thermal conditions in 4% of months in critical years	Shasta Framework, annual Temperature Management Plans, technical and policy team coordination during real-time operations, and adaptive management
Sacramento River	Spring Operations	Juvenile rearing and out-migration	Stranding Risk ● Highest in February and March ● Low of 3,544 in dry years (with caveats described the effects analysis that these are likely overestimates) ● High of 7,973 in wet years (with caveats described the effects analysis that these are likely overestimates)	Ramping rates
Sacramento River	Summer Operations	Adults and rearing juveniles	Pathogens and Disease ● 59.9°F threshold exceeded in 13.5% of months in critical years	Shasta Framework, annual Temperature Management Plans, technical and policy team coordination during real-time operations, and adaptive management

Division/Water body	Seasonal Operations Period	Affected Life Stage	Summary of Primary Stressors and Effects of the Proposed Action	Relevant Management Actions
American River	Summer and Fall Operations	Juvenile rearing	Water temperature ● Summer temperatures range from 63°F to 72°F at Watt Avenue and 50% of months across all years exceed threshold for increased virulence and susceptibility to disease	Minimum instream flows/minimum release requirement, water temperature management
American River	Summer and Fall Operations	Juvenile rearing	Stranding Risk ● Summer and fall flow fluctuations strand individuals	Minimum instream flows/minimum release requirements, water temperature management
American River	Summer and Fall Operations	Adult migration	Water Temperature ● 16% of months have temperatures that impair/block adult upstream migration at Watt Avenue, 2% of months block migration at Hazel ● 38% to 45% of months water temperatures exceed thresholds that increase virulence and susceptibility to disease	Minimum instream flows/minimum release requirements, water temperature management
American River	Winter and Spring Operations	Juvenile rearing	Stranding Risk ● Winter and spring flow fluctuations strand individuals, especially from March and April	Minimum instream flows/minimum release requirement, water temperature management
American River	Winter and Spring Operations	Juvenile rearing	Water temperature ● Threshold for smoltification exceeded 41% of months at Watt Avenue Bridge and 20% of months at Hazel	Minimum instream flows/minimum release requirement, water temperature management
American River	Winter and Spring Operations	Spawning Adults	Spawning Habitat ● Flows and habitat support up to 150 acres of spawning habitat	Minimum instream flows/minimum release requirements, water temperature management

Division/Water body	Seasonal Operations Period	Affected Life Stage	Summary of Primary Stressors and Effects of the Proposed Action	Relevant Management Actions
American River	Winter and Spring Operations	Spawning Adults	Water Temperatures ● Exceed targets 4% of months at Hazel and 9% of months at Watt	Minimum instream flows/minimum release requirements, water temperature management
American River	Winter and Spring Operations	Incubating eggs	Redd Dewatering ● Large flow fluctuations cause dewatering mainly between January and March	Minimum instream flows/minimum release requirements, water temperature management
American River	Winter and Spring Operations	Incubating eggs	Water Temperature ● 43% to 55% of months outside of optimal range for egg incubation at Hazel and Watt Avenue ● Increasing egg stress and mortality at Watt Bridge beginning in March as average temperature exceeds 54°F ● Increasing egg stress and mortality at Watt Bridge beginning in mid-April as average temperature exceeds 54°F	Minimum instream flows/minimum release requirements, water temperature management
Stanislaus	Fall, winter and spring operations	Adults	Water temperature ● Exceed thresholds threshold for impairing adult migration in ~3% of months and 25% of years ● Exceed thresholds for impairing gamete viability in 10.5% of months ● 59.9 threshold for increased virulence exceeded in 1% of months in 25% of all years	Minimum instream flows, Stanislaus Watershed Team

Division/Water body	Seasonal Operations Period	Affected Life Stage	Summary of Primary Stressors and Effects of the Proposed Action	Relevant Management Actions
Stanislaus	Fall, winter and spring operations	Egg incubation	Water temperature ● 54°F mortality threshold exceeded in an average of 49% of months with a low of 6% of months in January and a high of 94% of months in May	
Stanislaus	Fall, winter and spring operations	Juveniles	Water temperature ● Exceed optimal levels for growth and survival in 2.3% of months ● Exceed levels that impair smoltification an average of 27% of years ● 59.9°F threshold for increased virulence exceeded in 1% of months in 25% of all years	Minimum instream flows, Stanislaus Watershed Team
Stanislaus	Fall, winter and spring operations	Juvenile rearing	Flow conditions ● Spring pulse flows and winter instability flows improve juvenile out-migration cues and adult upstream migration cues ● Weighted Usable Area averages is 1,246,593, low in critical years of 1,211,607, high in wet years of 1,272,542 ● Suitable rearing habitat averages 718,884, low in critical years of 662,022, high in wet years of 808,569	Minimum instream flows, Winter Instability Flows, Spring Pulse Flows, Stanislaus Watershed Team

Division/Water body	Seasonal Operations Period	Affected Life Stage	Summary of Primary Stressors and Effects of the Proposed Action	Relevant Management Actions
Stanislaus	Summer	Juvenile rearing	Water temperature ● Exceeds thresholds for increased virulence an average of 75.3% of months, a low of 54.1% of all Junes, and a high of 96.9% of all Julys ● Exceeds temperatures of optimal growth conditions in 89% of months ● Exceeds temperatures that trigger low dissolved oxygen concentrations in less than 1% of years	Minimum instream flows, Stanislaus Watershed Team
San Joaquin River - Stanislaus River to Vernalis	Fall, Winter and Spring Operations	Adults	Water temperature ● Exceeds thresholds for increased virulence 12% to 34% of time with low rate in above normal years and the highest in critical years ● Exceeds thresholds for impairing upstream migration in 12% to 34% of time with lowest rate in above normal years and the highest in critical years	From the Stanislaus: Minimum instream flows, Winter Instability Flows, Spring Pulse Flows, Stanislaus Watershed Team
San Joaquin River - Stanislaus River to Vernalis	Fall, Winter and Spring Operations	Adults	Flow Conditions ● Building storage on the Stanislaus may impair upstream migration cues	From the Stanislaus: Minimum instream flows, Winter Instability Flows, Spring Pulse Flows, Stanislaus Watershed Team
San Joaquin River - Stanislaus River to Vernalis	Fall, Winter and Spring Operations	Juveniles	Water temperature ● Exceeds thresholds for increased virulence 12% to 34% of time with lowest rate in above normal years and the highest in critical years	From the Stanislaus: Minimum instream flows, Winter Instability Flows, Spring Pulse Flows, Stanislaus Watershed Team

Division/Water body	Seasonal Operations Period	Affected Life Stage	Summary of Primary Stressors and Effects of the Proposed Action	Relevant Management Actions
San Joaquin River - Stanislaus River to Vernalis	Fall, Winter and Spring Operations	Juveniles	Flow Conditions ● Building storage on the Stanislaus River may impair upstream migration cues	From the Stanislaus: Minimum instream flows, Winter Instability Flows, Spring Pulse Flows, Stanislaus Watershed Team
Delta	Summer and Fall Operations	Juvenile rearing and out-migration	Routing and entrainment risk at the Delta Cross Channel ● Risk of entrainment at the Delta Cross Channel in summer and fall for very low numbers of juveniles when gates open	Delta Cross Channel Closures, technical and policy team coordination during real-time operations, and adaptive management
Delta	Summer and Fall Operations	Juvenile rearing and out-migration	Routing into Central and South Delta and entrainment at export facilities ● Risk of routing and entrainment for very low numbers of juveniles	Annual loss thresholds, technical and policy team coordination during real-time operations
Delta	Winter and Spring Operations	Juvenile rearing and out-migration	Routing and entrainment risk at the Delta Cross Channel ● Risk of entrainment at the Delta Cross Channel from December 1 to January 31 if gates are opened for D-1641 water quality actions ● Risk of entrainment at the Delta Cross Channel when gates are opened for a total of 14 days from May 21 to June 15.	

Division/Water body	Seasonal Operations Period	Affected Life Stage	Summary of Primary Stressors and Effects of the Proposed Action	Relevant Management Actions
Delta	Winter and Spring Operations	Juvenile rearing and out-migration	Routing and entrainment risk at the state and federal export facilities ● Risk of salvage and loss at the state and federal export facilities ● Risk of predation and other sources of mortality in the entrainment footprint ● Potential risk from implementing the storm flex action	OMR (Old and Middle rivers) Flow Management ● Start of OMR Management ● Real-time adjustments ● Storm flex protective criteria ● Annual Loss Thresholds ● Weekly Distributed Loss Thresholds ● Storm flex protective criteria ● Future use of a Juvenile Production Estimate as a tool for scaling loss triggers to population size
Delta	Winter and Spring Operations	Juvenile rearing and out-migration	Spring Delta Outflow ● Potential to use this action to reduce entrainment risk	Spring Delta Outflow Action and governance through technical and policy teams to schedule volumes
Delta	Winter and Spring Operations	Juvenile rearing and out-migration	Agricultural Barrier Operations ● Passage impediments increase exposure to predation in May and June	Technical and policy team coordination

9.5.2.1. Water Temperature Management

Temperature management operations in Clear Creek will continue to benefit rearing juvenile and migrating adult CCV steelhead, although temperatures can exceed optimal levels for rearing on lower reaches of Clear Creek during late summer months. The combined effects of ongoing operations and the implementation of the proposed action are expected to be an improvement over baseline conditions.

Water temperatures in the Sacramento River can be elevated during critical years closer to Keswick Dam and moving downstream; modeling shows elevated risk of adult pathogen susceptibility and elevated spawning temperature conditions downstream near Red Bluff Diversion Dam to Hamilton City, which is 40 to 90 miles downstream from Keswick Dam.

California Central Valley steelhead in the Stanislaus River will continue to be negatively affected by certain elements of the proposed action. Specifically, CCV steelhead in the Stanislaus River will continue to be exposed to stressful water temperatures during adult

immigration, egg incubation, juvenile rearing, and smolt emigration. Flow-dependent habitat availability is limited, particularly for the spawning, juvenile rearing, and smolt emigration life stages.

The survival and growth of CCV steelhead in the Stanislaus River are affected by release levels below Goodwin Dam, which control the extent of cold water habitats and affect the quantity and functionality of instream habitat. In some reaches, particularly areas below Orange Blossom Bridge, CCV steelhead will be subjected to occasional sublethal and lethal effects of elevated temperatures from the egg through smolt stages. Direct mortality associated with the proposed action in the Stanislaus River is also expected through potential redd dewatering and other sources.

9.5.2.2. Pulse Flows

Clear Creek seasonally variable instream flows are designed to address the needs of multiple species across different seasons but may limit rearing habitat in some reaches. The proposed channel maintenance and spring pulse flows are expected to improve juvenile rearing habitat access and migration conditions from January through June, when most juveniles are expected to out-migrate. Such pulses would also expose juveniles to an increased risk of stranding and increase the likelihood of redds being dewatered when flows recede; however, effects to redds are predicted to be minimal because redd surveys have not detected any dewatering in the past under similar flow conditions and down ramping rates should minimize the risk of stranding juveniles. Pulse flows are also expected to improve habitat-forming processes over current conditions.

Seasonal pulse flows on the Sacramento River may improve out-migration survival of CCV steelhead individuals from Clear Creek, the Sacramento River, and numerous other tributaries downstream to the Delta.

Flow fluctuations on the American River from flood control releases can result in redd dewatering and juvenile isolation, particularly in the reach from Nimbus Dam downstream to the vicinity of Watt Avenue from December through early April. However, Reclamation's proposed ramping rate restrictions and redd dewatering protective adjustments are expected to limit these effects. Warm summer water temperatures from Nimbus Dam downstream past Watt Avenue can also result in adverse physiological effects to rearing juvenile CCV steelhead, triggering an increased susceptibility to disease and predation, although this effect would be most significant from Watt Avenue downstream. New proposed temperature management operations are expected to slightly reduce the thermal stress that juveniles are exposed to during the summer and fall compared to current operations. However, exposures to daily mean water temperatures will likely continue to occur and become more frequent under predicted climate change conditions. The combined effects of ongoing operations and implementation of the proposed action on the adult spawning, egg incubation, juvenile rearing, and smolt emigration life stages of CCV steelhead in the American River are not expected to reduce the current productivity, diversity, and abundance of the individuals and viability of the population.

On the Stanislaus River, Reclamation proposed three types of pulse flows: fall pulse flows, winter instability flows, and spring pulse flows. The fall pulse flow(s) action is intended to improve instream flow conditions on the Stanislaus River. This flow volume would occur in October or November, so its influence on spawning would be negligible, but it would help with

habitat diversity and food production. The winter instability flows will improve Stanislaus River conditions related to out-migration cues and juvenile rearing habitat access. The spring pulse flows are intended to recreate some of the variability in the otherwise regulated and stable flows associated with seasonal operations. This element of the proposed action would improve migration conditions for juvenile salmonids migrating in the March to June timeframe improving survival.

9.5.2.3. Stranding Risk and Ramping Rates

On the Upper Sacramento River, the modeling predicts the stranding of 4,434 CCV steelhead juveniles under the proposed action in critical years. However, this is likely an overestimate: estimates of juvenile stranding are an order of magnitude greater than observed in recent years for all species, and, therefore, the results are better interpreted as relative differences. The rates are similar to current conditions.

Stranding could also occur on Clear Creek and the American and Stanislaus rivers. Ramping rates, specifically developed for these watersheds, will be used as a minimization tool to reduce stranding during periods of flow fluctuation brought upon by seasonal flow management.

9.5.2.4. Operation of the Delta Cross Channel Gates

Another important component of the proposed action that would affect the survival of CCV steelhead is the potential increase in routing through the Delta Cross Channel compared to a modeled current operations, resulting in increased juvenile mortality due to routing into the Delta interior, with lower survival rates due to increased migration times with concurrent increased exposure to predators. From December 1 to January 31, the Delta Cross Channel gates will be closed, except to prevent exceeding a D-1641 water quality threshold. From February 1 to May 20, the Delta Cross Channel gates will be closed consistent with D-1641. From May 21 to June 15, Reclamation will close the Delta Cross Channel gates for a total of 14 days consistent with D-1641. Reclamation and DWR's risk assessment will consider the Knights Landing rotary screw trap, Delta Juvenile Fish Monitoring Program (Sacramento River trawl, beach seines), Rio Vista flow standards, and acoustic telemetered fish monitoring information, as well as DSM2 modeling informed with recent hydrology, salinity, and tidal data. Reclamation will evaluate this information to determine the timing and duration of the gate closure. We expect these measures to provide protections that are similar to the protections analyzed in the NMFS 2019 opinion (National Marine Fisheries Service 2019b).

For CCV steelhead smolts emigrating from December through April, there would be little difference between the proposed action and current operating scenario (NAA) regarding routing and travel times. Therefore, through-Delta survival under the two scenarios should be similar. This is when most CCV steelhead from the Sacramento River basin emigrate through the Delta. From mid-April through June, the slight increase in flows coming into the Delta under the proposed action scenario should help reduce both travel time through the Delta and routing into the Delta interior at river junctions compared to the current operating scenario. These changes should increase through-Delta survival, although the fraction of the CCV steelhead affected during this period would be quite low as most CCV steelhead from the Sacramento Basin have already emigrated.

Delta Cross Channel gate operations are also likely to continue to delay the migration of some CCV steelhead adults, although most are expected to enter the Delta when the gates are open (August through November). A proportion of the adults affected by the gate operations will be more likely to stray into the San Joaquin River and Mokelumne River system. These adults will be able to continue migration back into the Sacramento River until the gates are closed in December, at which point late-migrating adults that have strayed into this system will be impeded. Adults still entering the system after November will be less likely to stray into the Mokelumne River system and be delayed.

9.5.2.5. Old and Middle River Management and Entrainment and Loss at the Delta Export Facilities

The action of pumping water from the South Delta export facilities is another major component of the proposed action that would affect CCV steelhead. OMR flow management is used to reduce the entrainment of fish, including CCV steelhead, into the southern Delta and loss of fish at the export facilities. OMR management includes multiple action components that target different seasons and species. There are several action components developed for salmon and steelhead that manage OMR flows to minimize salvage and loss at the CVP and SWP export facilities including:

- **Start of OMR Management:** The OMR management season begins either on December 1 or December 20, depending on certain smelt protection actions being triggered. Once the OMR management season starts, the OMR index, on a 14-day running average, will be no more negative than -5,000 cfs until the end of the OMR season.
- **Steelhead Annual Threshold:** This element is intended to keep annual loss from exceeding certain historical levels. OMR flows are adjusted to be less negative when thresholds are exceeded, which is intended to help curb escalating levels of loss.
- **Steelhead Weekly Distributed Loss Threshold:** This element is intended to minimize the potential for disproportionate impacts of entrainment on any single week that CCV steelhead are in the Delta.
- **Storm Flex:** This action could potentially offramp the -5,000 cfs to be no more negative than -6,250 cfs prior to the last day of February.
- **End of OMR Management Season:** OMR management season concludes on June 30 or when water temperatures at Mossdale and Prisoner's Point exceed 71.96°F for 7 non-consecutive days; whichever happens first.

Elements of the proposed action, including the weekly distributed loss thresholds, and the addition of a new temperature compliance point will provide more conservative off-ramping to end the season.

The zone of influence for the effects of this component of the proposed action is concentrated in the South Delta, where populations of the Southern Sierra Nevada diversity group would have the greatest exposure. Populations entering the Delta via the Sacramento River, such as SR winter-run Chinook salmon, are less exposed to these effects as the extent of hydrodynamic influence of Delta export operations diminishes with distance from the export facilities.

We estimate there are approximately 25 populations of CCV steelhead from four diversity groups that will be exposed to the effects of this element of the proposed action. California Central Valley steelhead originating in the Sacramento River watershed, whose migration route

includes Georgiana Slough (15 to 20 percent of individuals), would be subject to the effects of South Delta exports. Likewise, about 50 to 65 percent of juvenile CCV steelhead originating from the San Joaquin River or its tributaries will be routed into the Old River. Individual fish that enter the Delta through these pathways are expected to have lower survival. NMFS assumes a change in CCV steelhead through-Delta survival similar to the Chinook salmon runs (0 to 3 percent) associated with operations.

The detailed effects of South Delta export discretionary operations and OMR management are discussed in the Bay-Delta Division effects analysis section of this opinion. We do not have a survival model that is calibrated to CCV steelhead acoustic telemetry data, so no through-Delta survival estimates are available for CCV steelhead. The main line of evidence that we consider here is the estimates of loss at the salvage facilities using the Salvage Density Analysis.

Under current operations (NAA), predicted salvage ranges from a low of 403 fish in below-normal years to a high of 1,509 fish in wet years. The predicted annual loss of CCV steelhead at the facilities under the proposed action ranges from a low of 387 fish in critical years to a high of 1,488 in wet years. The lowest predicted loss occurred in proposed action phases for below normal water year types. The highest predicted loss occurred in proposed action phases for wet water year types. Loss of CCV steelhead at the facilities in the proposed action phases ranges over an order of magnitude among water year types, which is similar to historically observed salvage in the recent past.

Overall, the modeling available for the analysis shows that OMR management will have similar effects as those modeled under current operations, but the early-season approaches and weekly loss thresholds, although specifically designed to protect other species, will provide indirect improvements to minimize disproportionate loss of any part of the population, which should help protect life history diversity.

9.5.2.6. Spring Outflow

This element of the proposed action is specific to the proposed pre-adoption period of the Delta component of the VAs, which is a volumetric export reduction action but qualitatively considers DWR's proposal to implement export reductions based on San Joaquin River flows measured at Vernalis until the post-adoption period of the Delta component of the VAs. If the SWRCB approves VAs, the programmatic section of this opinion describes how they may be implemented. Because the zone of influence for the effects of this element of the proposed action is centered in the South Delta, populations of the Southern Sierra Nevada diversity group would have the greatest exposure. Populations entering the Delta via the Sacramento River, would be less exposed to the effects of this element.

California Central Valley steelhead potentially exposed to this proposed action element include populations originating in the Sacramento and San Joaquin basins from an estimated 25 naturally spawning populations and four diversity groups. About 50 percent of juvenile CCV steelhead originating from the San Joaquin River or its tributaries in dry to above normal water year types (56 percent of years) will be exposed to the improved migratory and rearing conditions in the interior Delta, leading to an increase in productivity for those populations. Likewise, about 50 percent of the Sacramento River watershed-origin CCV steelhead, whose migration route includes Georgiana Slough in dry to above-normal water year types (56 percent of years), would be exposed to the improved migratory and rearing conditions in the interior Delta leading to an

increase in productivity for those populations. These conditions are expected for the first 2 years of implementation, with some to a lesser degree of this improvement continuing due to DWR's commitment to manage spring outflows until VAs are in place.

9.5.2.7. Governance and Adaptive Management

The Governance element of the proposed action describes the proposed engagement of participating state and federal agencies, interested parties, and the public and how they will work together during implementation. Governance establishes the teams and principles that are subject to ongoing collaborative implementation and decision-making and identifies the processes for working together and for elevating and resolving matters when there is a lack of consensus. For such a large and complicated project, Governance is essential for ensuring implementation is carried out as described in the proposed action, including the complicated interface between real-time operations and the ongoing technical and management discussions that inform operations and species protections, and that it remains within the bounds of the analysis in this opinion.

The proposed action also includes an AMP as a structured, iterative process for decision-making when confronted with uncertainty. Adaptive management emphasizes learning through management where knowledge is incomplete and provides a process for building knowledge through monitoring and science, reducing uncertainty, and improving management over time in a goal-oriented and structured way. The AMP and related special studies include over 20 actions, and while they may not individually or collectively change the impacts of project-related effects on CCV steelhead, they are expected to improve management at some level and to inform actions that affect species risk.

One of the special studies proposed by Reclamation is the development of a JPE for CVP tributaries and the implementation of sequential science plans for the Sacramento River basin and San Joaquin River basin. The studies are intended to be carried out in the context of adaptive management, but they currently lack specificity to understand how or when a JPE might be in place for management purposes.

9.5.2.8. Programmatic Actions

The opinion includes certain action components that were analyzed as framework-level programmatic actions for the development of future actions that may be authorized, funded, or carried out at a later time, and any take of a listed species would not occur unless and until those future actions are authorized, funded, or carried out and subject to further ESA section 7 consultation. We analyzed the effects of those actions qualitatively to understand how they might be carried forward in the context of water operations. The following framework programmatic actions are considered in this opinion:

- The Sites Reservoir Project: Adverse and beneficial effects to listed species and designated critical habitat. A broad suite of potential effects to individuals and PBFs of designated critical habitat are proposed to be minimized or avoided through established guiding principles, best management practices, adaptive management strategies, and monitoring and compensatory mitigation strategies. Project components include bypass and pulse flow criteria, monitor and mitigate the effects of diversions, habitat restoration, and use of the best available science to develop and implement operations plans.

- The Delta Conveyance Project: Adverse and beneficial effects to listed species and designated critical habitat. A broad suite of potential effects to individuals and PBFs of designated critical habitat are proposed to be minimized or avoided through established guiding principles, best management practices, adaptive management strategies, and monitoring and compensatory mitigation strategies. Project components include bypass and pulse flow criteria, monitor and mitigate the effects of diversions, habitat restoration, and use of the best available science to develop and implement operations plans.
- Spring Outflow - Post-Adoption of VAs: This action is expected to result in improved flow conditions and reduced entrainment for listed species in the Delta during April and May and improved survival over baseline for rearing and migration. These responses are consistent with the objectives of the long-term operations of the CVP and SWP to implement actions that reduce entrainment and improve survival through the Delta. These responses would mostly affect juvenile fish in particular, as they are most susceptible to entrainment and flow-related survival. There may also be some responses to juvenile rearing and survival during spring months on the Sacramento and American rivers during certain water year types. Risks to listed species are low.
- Drought Response (i.e., Drought Toolkit): The Drought Response action includes components designed to avoid or mitigate the effects of drought. A drought planning team will evaluate the need for drought actions annually and propose them on a case-by-case basis. Given the framework-level programmatic nature of this action, it is possible to estimate the specific impacts but the overall objective is to consider and implement actions that avoid or mitigate drought-related consequences to listed species and their critical habitat.
- Monitoring: Many ongoing monitoring programs that inform operational actions and effects are currently under existing and separate ESA section 7 consultations and section 10(a)(1)(A) permits and considered in the Environmental Baseline section of this opinion. Potential future changes to monitoring programs associated with the operation of the CVP and SWP will be addressed in separate ESA section 7 consultations that are tiered to the consultation. Subsequent changes to existing monitoring programs would be coordinated and included in future consultations of the LTO of the CVP and SWP to allow for a more uniform analysis and improved accounting of incidental take coverage associated with the operation of the CVP and SWP.
- Tidal Habitat Restoration: Tidal habitat restoration will result in near-term impacts to aquatic and riparian habitat leading to lethal and sublethal impacts to listed species, but the risks to individuals will be avoided, minimized and mitigated through long-established best management practices. Post-construction habitat conditions will benefit the growth and survival of listed species and improve the conservation value of critical habitat.
- Adaptive Management and Special Studies: The Adaptive Management Program will utilize decision support tools such as structured decision-making to improve future management decisions to improve the operations of the CVP and SWP for project purposes. Most of the actions will improve the are intended to improve the capacity and precision of the projects to protect listed species.

9.5.3. Climate Change Considerations

Future projections over the duration of the proposed action (i.e., through 2030), considering climate change, exacerbate some of the proposed action risks to CCV steelhead. For example, climate change is expected to further degrade the suitability of habitats in the Central Valley through increased temperatures, increased frequency of drought, increased frequency of flood flows, and overall drier conditions (Lindley et al. 2007). However, the temperature and flow management actions proposed generally increase flows and reduce water temperatures during the warmest times of year, and would therefore be expected to minimize these effects.

The proposed action includes measures to address climate change. For CCV steelhead, these include the application of climate change scenarios in the CalSim modeling, the continued use of conservative forecasts and the collaborative process of SRG and SHOT coordination, especially regarding timing and shaping of spring flows, and the use of Drought Planning and the Drought Toolkit.

9.5.4. Risk to California Central Valley Steelhead Distinct Population Segment

California Central Valley steelhead are composed of multiple populations across four diversity groups. Based upon the limited information available, the overall viability of the CCV steelhead DPS appears to be unchanged since the NMFS (2016b) 5-year review. However, the majority (11 of 16) of populations for which there are data are at a high risk of extinction based on abundance and/or hatchery influence, with no population considered to be at a low risk of extinction. The lack of improved natural production estimates, and low abundances coupled with large hatchery influence are causes for continued concern.

The proposed action includes many components that have been developed through iterative, collaborative and scientific processes over the past 15 years, and through the development of the proposed action that is subject to this consultation. These include refined approaches for managing temperatures and storage at Shasta; improved processes for technical, scientific and policy coordination which should provide more responsive decision making when Shasta or Delta conditions are stressed; and refined approaches for managing OMR with weekly loss triggers that should allow for more careful management of loss during periods of periodically high salvage.

Regardless of the iterative improvements, the proposed action will continue to result in ongoing adverse effects to CCV steelhead. Here we discuss them in the context of the CCV steelhead Diversity Groups:

9.5.4.1. Northwestern California

Habitat in Clear Creek below Whiskeytown Dam is believed to be historically unsuitable for CCV steelhead spawning and rearing (Lindley et al. 2006). As a result, CCV steelhead habitat on Clear Creek must be maintained by releases from Whiskeytown Dam, and any level of degradation to the functioning of that habitat further limits its value for the conservation of the species. Reclamation proposes to maintain suitable minimum base flow and temperature management in Clear Creek, and includes channel maintenance and spring attraction pulse flows. Minimum instream base flows are expected to continue to inhibit habitat-forming processes and restrict habitat access, although continued exposure to unsuitably warm temperatures is likely much less frequent than what would occur without ongoing temperature management operations.

Under the proposed action, spring attraction and channel maintenance pulse flows are expected to improve spawning habitat quality and quantity by mobilizing and dispersing gravel and reducing fine sediment, and provide improvements to juvenile rearing habitat and the fresh water migratory corridor compared to current conditions, although pulse flows also have the potential to strand a small proportion of juveniles and dewater redds.

Temperature impacts on Clear Creek, which is in the CCV steelhead Northwestern California Diversity Group, are largely expected to be within ranges that support survival for egg incubation, juvenile, and adult life stages; however, temperatures can exceed optimal levels rearing on lower reaches of Clear Creek during late summer months creating a potential migratory barrier between the Sacramento River and Clear Creek. The combined effects of ongoing operations and the implementation of the proposed action on the adult spawning, egg incubation, juvenile rearing, and migration life stages of CCV steelhead in Clear Creek are expected to maintain or slightly improve the productivity, diversity, and abundance of the individuals and viability of the population compared to current conditions.

Overall, while still impaired, the Clear Creek population productivity and abundance are expected to be slightly improved over current conditions due to the proposed action. This is the only Core 1 population within the Northwestern California diversity group; the three other populations are not impacted by the proposed action. As the Clear Creek population is in the only watershed known to be able to support a viable population within this diversity group, uplift to this population from the proposed action is expected to benefit the overall viability of the Northwestern California diversity group.

9.5.4.2. Basalt and Porous Lava

This diversity group historically included spawning populations in the Little Sacramento, McCloud, and Pit rivers above Shasta Dam, which are no longer accessible. The only remaining available habitat now utilized by CCV steelhead in the Basalt and Porous Lava diversity group is in the mainstem Sacramento River below Keswick Dam, Cow Creek, Battle Creek, and Redding area tributaries. Habitat in some of these areas is highly degraded. Only one of the four populations in the Basalt and Porous Lava diversity group of this DPS, in the Sacramento River and Battle Creek, are likely to be affected by the proposed action.

Water temperatures in the Sacramento River, which is in the CCV steelhead Basalt and Porous Lava Diversity Group, result in elevated risk of adult pathogen susceptibility and elevated spawning temperature conditions downstream near Red Bluff Diversion Dam to Hamilton City, and egg incubation can be elevated during critical years closer to Keswick Dam. Still, temperatures are generally much better during other water year types, as evidenced by high levels of *O. mykiss* production in the upper river.

Proposed changes to Shasta operations should provide better summer temperatures for rearing juveniles than current operations, although lower minimum flows in the fall and winter will also increase the risk of juvenile stranding and may lead to increased instances of redd dewatering during the winter months. While the proposed action is not expected to appreciably increase the productivity or abundance of Upper Sacramento River CCV steelhead, a series of response, collaboration, and intervention actions are proposed to ensure that proposed action effects fall within those considered in this opinion and are not further compromising the status of this population. While not a Core 1 population, the Sacramento River population of CCV steelhead

still plays an important role in maintaining the life history diversity and viability of the diversity group as a whole.

9.5.4.3. Northern Sierra Nevada

The American River population of CCV steelhead is one of several within this diversity group. However, the current population is primarily composed of hatchery-raised CCV steelhead. Water temperature is expected to continue to be a medium to high magnitude stressor on American River steelhead, although summer and fall temperatures for rearing juveniles should be slightly improved compared to current conditions. Flow management and fluctuations will also continue to be a source of juvenile stranding, redd dewatering, and limited juvenile rearing habitat for CCV steelhead. There are ongoing habitat restoration actions in the American River under the proposed action.

California Central Valley steelhead in the American River will continue to be negatively affected by certain elements of the proposed action. Specifically, CCV steelhead will continue to be exposed to stressful water temperatures during summer rearing, especially in drier water year types.

Considering that the American River population is one of several populations in this diversity group, but is heavily influenced by out-of-basin hatchery fish and also is not in a Core 1 watershed, the proposed action effects on the American River population are not expected to reduce the overall viability of the Northern Sierra Nevada diversity group.

9.5.4.4. Southern Sierra Nevada

Only the Stanislaus River population of the Southern Sierra Nevada diversity group is expected to be affected by the proposed action. While in a Core 2 watershed, preservation of this population is important to maintaining the life history diversity and spatial structure of the diversity group as a whole.

On the Stanislaus River, water temperatures can also impact adult immigration, egg incubation, juvenile rearing, and smolt emigration. Flow operations in the Stanislaus River are expected to continue to reduce the growth and survival of juvenile CCV steelhead by restricting access to suitable rearing habitat and providing poor migration conditions for adults and juveniles, consistent with current conditions.

Considering that the Stanislaus River population is one of three populations in this diversity group but not in a Core 1 watershed, the proposed action effects on the Stanislaus River population are not expected to reduce the overall viability of the Southern Sierra Nevada diversity group.

9.5.4.5. Risk to California Central Valley Steelhead at the Distinct Population Segment-Scale

Seasonal pulse flows, although not coordinated across tributaries, are often timed to take advantage of natural high flow conditions and can provide improved juvenile out-migration cues and improve survival conditions for multiple populations and across several Diversity Groups. Pulse flows also, to some extent, manipulate channel morphology, which can improve in-river habitat conditions that are beneficial for food production and spawning and rearing habitat.

Seasonal operations can also create circumstances that strand and kill juvenile fish and those conditions will be minimized through ramping rates.

In the Delta, the action will result in adverse effects related to routing into the Central Delta through the Delta Cross Channel and near and far-field effects from project-related changes in Delta hydrodynamics. At the Delta export facilities, operations of the pumps will result in entrainment into the export facilities, where fish can be injured and/or lost to predation and other factors. While Reclamation and DWR's discretionary impacts to CCV steelhead are higher than the under obligated release scenarios, the modeled impacts on the species indicate the proposed action's impacts will not be substantially different than current operations. Refinements to loss management will include weekly loss thresholds that will reduce the potential for instantaneous spikes in salvage before actions are taken to minimize the zone of influence that may be driving salvage and loss. Spring outflow actions, while not having a large influence on CCV steelhead, will provide modest reductions in salvage and loss. We expect that populations in the Southern Sierra Diversity Group will be disproportionately affected by export operations because they are closer to and more prone to the routing effects and junctions such as the Head of Old River.

As summarized above and discussed in the Delta Effects Analysis section of the opinion, Buchanan et al. (2021) analyzed the results of a multi-year drought study of through-Delta survival of acoustic-tagged steelhead released in the mainstem San Joaquin River just upstream of the Delta. Under conditions likely similar to what is expected under the proposed action, through-Delta survival ranged from 6 percent to 69 percent and was positively related to San Joaquin River inflow and to the ratio of Vernalis inflow to combined CVP and SWP exports. Through-Delta survival was also positively related to CVP exports, though survival was negatively related to SWP exports alone and to combined CVP and SWP exports.

The proposed action includes measures to address the effects of climate change and drought, including an improved governance and decision-making process, the use of conservative forecasts to make operational decisions, and the continued use of a Drought and Dry Year Actions toolkit.

As described in the Analytical Approach of this opinion, the risk to the CCV steelhead DPS posed by the proposed action is evaluated in the aggregate context of the effects of the species' status, the environmental baseline, cumulative effects, and effects from interrelated and independent actions. In total, NMFS expects that despite ongoing adverse effects of the CVP and SWP on individuals and their respective populations, and the continued and significant adverse effects that are part of the environmental baseline, such as the loss of historical habitat related to the physical presence of Keswick and Shasta dams, the proposed action includes measures intended to maintain and, in some cases, improve the survival of individuals.

The assessment of risk also considers VSP parameters as summarized in Table 178.

Table 178. Summary of Viable Salmonid Population (VSP) parameters considered in the analysis of effects.

VSP Parameter	Proposed Action Considerations	VSP Considerations
Abundance	Delta Operations: Juvenile Production Estimate (JPE)-based OMR (Old and Middle rivers) triggers and actions, and risk assessments	The proposed action has population-scale impacts to adult abundance. At the DPS scale, three of the Central Valley Project tributaries support Core 2 populations (Sacramento, American, and Stanislaus rivers), and 1 Core 1 population (Clear Creek). Water temperature management has a positive influence on adult abundance in Clear Creek. *O. mykiss* abundance is high on the mainstem Sacramento River and ongoing and proposed water operations continue to influence CCV steelhead DPS abundance. Adult abundance on the American River is strongly influenced by Nimbus hatchery operations.
Productivity	Delta Operations: JPE-based OMR triggers and actions, risk assessments	Productivity considerations are integrated into the proposed future development of an annual JPE.
Diversity and Spatial Structure	In the Delta: Use of annual and weekly loss thresholds and weekly risk assessments	Annual and weekly loss thresholds with triggers and management actions minimize disproportionate impacts on juvenile out-migrants across the juvenile migration season.
Habitat Capacity and Diversity	Water Temperature: Especially during critical and dry water year types and summer months	Water temperature management plans and technical and policy group coordination work in real time to minimize operational impacts.

Several elements of the proposed action are aligned with or directly implement recovery actions identified in the NMFS salmonid recovery plan (National Marine Fisheries Service 2014b).

The proposed action also does not impede the implementation of other key elements of the recovery plan, such as improving water conservation across California, incorporating ecosystem restoration in flood control planning, and improving salmon harvest monitoring and management. Implementation of the proposed action is, therefore, not creating conditions that would preclude recovery of CCV steelhead in the future. Should VAs be approved by the

SWRCB, this opinion may provide an efficient regulatory mechanism for permitting their implementation, as described in the proposed action.

Considering its current rangewide status, the environmental baseline within the action area, the effects of the proposed action, the effects of other activities, and cumulative effects, NMFS concludes that the proposed action is not likely to appreciably reduce the likelihood of both the survival and recovery of the CCV steelhead.

9.6. California Central Valley Steelhead Effects on Designated Critical Habitat

9.6.1. Summary of the Status of Designated Critical Habitat

As described in the Status of the Species and Critical Habitat section, the geographical extent of designated critical habitat for CCV steelhead includes the Sacramento, Feather, and Yuba rivers, and Deer, Mill, Battle, Clear, and Antelope creeks in the Sacramento river basin; the San Joaquin River, including its tributaries but excluding the mainstem San Joaquin River upstream of the Merced River confluence; and the waterways of the Delta. California Central Valley steelhead critical habitat is composed of four PBFs that include freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, and estuarine habitat. The PBFs for CCV steelhead designated critical habitat were described in 70 FR 52488 (September 2, 2005).

In general, stressors to CCV steelhead critical habitat PBFs of freshwater spawning, rearing sites, and migration corridors include water diversions and water management; dams and other structures; loss of floodplain connectivity; loss of natural riverine function and bank protection; dredging; sediment disposal; gravel mining; invasive aquatic organisms; and agricultural, urban, and industrial land use (McEwan 2001). Passage impediments in the Sacramento and San Joaquin river basins have contributed to substantial reductions in suitable habitat available to CCV steelhead by isolating them from much of their historical spawning habitat. The function of PBFs of available critical habitat is currently highly degraded. California Central Valley steelhead spawn in the accessible reaches of the Upper Sacramento River, Clear Creek, throughout the Lower American River, and in the Upper Stanislaus River. The PBFs of freshwater spawning habitat have been degraded by ongoing CVP operations within the action area due to reduced flows in reaches below dams, which limits recruitment of gravel for spawning substrate and habitat-forming processes, although adaptive flow management and restoration actions in the Sacramento and American rivers minimize these effects. Migratory corridors are also degraded by warmer water releases in the fall, particularly on the American River, although CVP operations also result in cooler downstream temperatures during summer months than would have existed under pre-dam conditions. Rearing and migration PBFs have also been degraded within the Sacramento and San Joaquin river basins by loss of natural river function and floodplain connectivity through flow regulation, water withdrawals, levee construction, direct loss of floodplain and riparian habitat; and effects to water quality associated with agricultural, urban, and industrial land use. Lasting impacts of habitat destruction from gravel mining and historical gold mining activities as well as ongoing activities in the Central Valley bays and Delta (including dredging, agricultural barriers, water exports, vessel traffic, and food web disruption from invasive species) continue to further limit habitat quality.

Based on the host of stressors to spawning, rearing, migratory, and estuarine habitats in the Central Valley, it is apparent that the current condition of CCV steelhead critical habitat is degraded.

9.6.2. Summary of Proposed Action Effects on Critical Habitat

Proposed action-related effects to CCV steelhead designated critical habitat are summarized below. Detailed descriptions regarding the effects of the proposed action on CCV steelhead designated critical habitat are presented in the Effects of the Action section.

9.6.2.1. Clear Creek

9.6.2.1.1. Status of California Central Valley Steelhead Critical Habitat in Clear Creek

The PBFs of CCV steelhead habitat in Clear Creek include freshwater spawning, rearing, and migration. Whiskeytown Dam, located at river mile 18.3 on Clear Creek, is an impassable barrier to adult anadromous salmonids and marks the upstream extent of potential CCV steelhead habitat. The McCormick-Saeltzer Dam blocked upstream migration of anadromous salmonids from 1903 until it was removed in the fall of 2000. Following its removal, approximately 12 miles of cold-water habitat upstream to Whiskeytown Dam was available. The construction of Whiskeytown Dam, gold mining, and significant gravel mining in the Clear Creek watershed has diminished the availability and recruitment of suitable spawning gravels. Channel restoration and gravel injection projects are conducted to make up for this loss of spawning gravel recruitment and suitable spawning habitat on Clear Creek.

9.6.2.1.2. Project Effects on California Central Valley Steelhead Critical Habitat in Clear Creek

The proposed action produces stressors to CCV steelhead critical habitat in Clear Creek that primarily affect rearing habitat. Flow regulation impairs natural river processes and decreases habitat complexity and variability, which limits the quality and quantity of rearing habitat. Additionally, low flows and warm water temperatures during the summer limit the availability of quality rearing habitat. Proposed spring and channel maintenance pulse flows are expected to improve spawning habitat quality to some extent compared to current conditions, although the magnitude and duration of flows would not be great enough to substantially improve PBF function in this reach.

9.6.2.1.3. Assess Risk to California Central Valley Steelhead Critical Habitat in Clear Creek

Habitat in Clear Creek below Whiskeytown Dam is believed to have been historically unsuitable for CCV steelhead spawning and rearing (Lindley et al. 2006). As a result, CCV steelhead habitat on Clear Creek must be maintained by releases from Whiskeytown Dam. The proposed action provides a seasonally variable hydrograph, with higher releases in the winter and lower releases in the summer, and also pulse flows for spring attraction and channel maintenance. The pulse flows are expected to improve spawning habitat quality and quantity by mobilizing and dispersing gravel and reducing fine sediment, and provide incremental improvements to juvenile rearing habitat and the freshwater migratory corridor. However, channel maintenance pulse flows would not provide the magnitude needed for channel shaping and floodplain inundation (3,000 to 6,000 cfs) because releases are limited by the outlet capacity at Whiskeytown Dam

(currently 840 cfs). The pulse flow volume under the proposed action will be reduced to half (i.e., 5,000 acre-feet) in critical water year types.

9.6.2.2. Mainstem Sacramento River

9.6.2.2.1. Status of California Central Valley Steelhead Critical Habitat in the Mainstem Sacramento River

Within the range of CCV steelhead, PBFs of the designated critical habitat that are considered vital for CCV steelhead include freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, and estuarine habitat. As generally described in the Status of Critical Habitat section, each of these biological features is considered to be degraded. Negative effects to rearing and migration habitats within the Sacramento River include loss of natural river function and floodplain connectivity through levee construction, direct loss of floodplain and riparian habitat, and effects to water quality associated with agricultural, urban, and industrial land use.

9.6.2.2.2. Project Effects on California Central Valley Steelhead Critical Habitat in the Mainstem Sacramento River

The proposed action negatively affects critical habitat for CCV steelhead from the mainstem Sacramento River in several ways. As shown in Table 179, the proposed action produces stressors to CCV steelhead spawning, rearing, and migratory habitat in the mainstem Sacramento River.

Table 179. Effects of the proposed action on the physical and biological features of California Central Valley steelhead designated critical habitat in the Sacramento River.

Life Stage	Action Component	Location of Effect	Physical and Biological Features (PBFs) Affected	Response and Rationale of Effect
Spawning Adults, Incubation of Eggs, and Rearing for Fry	Fall and Winter Operations	From Keswick Dam to Bend Bridge	Freshwater Spawning Sites	The operations of Shasta and Keswick dams mobilize spawning gravel and the presence of the dam in the Environmental Baseline limits the recruitment of clean gravel for spawning substrate as they block the downstream transport of gravels to the accessible reach of the river.
Freshwater Rearing Habitat for Juveniles		From Keswick Dam to the Delta	Freshwater Rearing Sites	Reduced flow variability decreases rearing habitat quantity and complexity.

Life Stage	Action Component	Location of Effect	Physical and Biological Features (PBFs) Affected	Response and Rationale of Effect
Freshwater Migratory Corridor PBFs for Out-migrating Juveniles and Spawning Adults	Spring Operations	From Keswick Dam to the Delta	Freshwater Migration Corridors	Reduced flow variability reduces cues for juvenile emigration and adult migration and habitat during the spring.

9.6.2.2.3. Assess Risk to California Central Valley Steelhead Critical Habitat in the Mainstem Sacramento River

Habitat within the mainstem Sacramento River below Keswick Dam is believed to be historically unsuitable for CCV steelhead spawning and rearing (Lindley et al. 2006). Migratory and rearing habitats in the middle Sacramento River are believed to be substantially degraded (National Marine Fisheries Service 2016b). As a result, CCV steelhead habitat on the mainstem Sacramento River must be maintained by releases from Keswick Dam. The proposed action results in a reduction in the quantity or quality of freshwater spawning and rearing sites and freshwater migration corridor as a result of seasonal operations affecting the suitability of rearing habitat in the middle Sacramento River. This reduction diminishes the ability of any CCV steelhead populations from the Sacramento Basin (e.g., mainstem Sacramento River and Clear Creek) to successfully rear in the Sacramento River or migrate to the Delta. Migratory and rearing PBFs of these habitats are not expected to change substantially under the proposed action.

9.6.2.3. American River

9.6.2.3.1. Status of California Central Valley Steelhead Critical Habitat in the American River

The PBFs of critical habitat for Lower American River CCV steelhead include freshwater spawning, freshwater rearing, and freshwater migration. There is a general consensus in the available literature suggesting that habitat for CCV steelhead in the American River is impaired (McEwan and Nelson 1991, Surface Water Resources Inc. 2001, Water Forum 2005). Of particular concern are warm water temperatures during embryo incubation, rearing, and migration; flow fluctuations during embryo incubation and rearing; and limited flow-dependent habitat availability during rearing. All of these concerns are related to water management operations of the CVP.

9.6.2.3.2. Project Effects on California Central Valley Steelhead Critical Habitat in the American River

The following summarizes the effects of the action on the PBFs of critical habitat in the American River:

- Freshwater Spawning Sites: Modest improvements over current conditions in habitat suitable for spawning and egg incubation (e.g., 3-percent decrease in redd dewatering; 1 to 3-percent improvement under the proposed action in the months with preferred spawning temperature range; 5-percent decrease in the percent of months above the adult pathogen susceptibility threshold at Hazel Avenue; and 2 to 5-percent increase in rearing habitat during most water years, but also 2-percent decrease during critical years).

- Freshwater Rearing Sites: Modest improvements over current conditions in juvenile rearing habitat (e.g., 1-percent improvement at Hazel Avenue and 2 percent at Watt Avenue in the percent of months above the threshold for the juvenile steelhead out-migration cue by water year type and for all years combined; and 6-percent improvement at Hazel Avenue and 4-percent improvement at Watt Avenue in the percent of months above the pathogen virulence water temperature threshold, but under proposed action temperatures will still exceed this threshold 43 percent of the time at Hazel Avenue and 50 percent of the time at Watt Avenue, averaged across all years).

- Freshwater Migration Corridors: Increase in habitat with suitable temperatures for migration (e.g., 7-percent decrease in the percent of months above the lethal water temperature limit for adult CCV steelhead migration in the American River at Watt Avenue, but also 1-percent increase in the same metric at Hazel Avenue; and 5-percent decrease in the percent of months above the adult pathogen susceptibility threshold at Hazel Avenue).

9.6.2.3.3. Assess Risk to California Central Valley Steelhead Critical Habitat in the American River

Habitat within the American River below Nimbus Dam is believed to be historically unsuitable for CCV steelhead spawning and rearing (Lindley et al. 2006). As a result, CCV steelhead habitat on the American River must be maintained by releases from Nimbus Dam. The proposed action will result in modest improvements in freshwater spawning sites, freshwater rearing sites, and freshwater migration corridors compared to current conditions, although in certain hydrologies or water year types, there will be increased degradation in water temperatures that would not provide for suitable freshwater rearing sites.

9.6.2.4. Delta

9.6.2.4.1. Status of California Central Valley Steelhead Critical Habitat in the Delta

The PBFs of critical habitat for CCV steelhead in the Delta include freshwater and estuarine rearing and migration. Estuarine habitats for CCV steelhead have been substantially degraded (e.g., Sommer et al. [2007]), and evidence of this includes the collapse of the pelagic community in the Delta and dramatic habitat changes related to water quality, toxic algae blooms (e.g., Microcystis), and invasive species (e.g., the aquatic macrophyte *Egeria densa*).

9.6.2.4.2. Project Effects on California Central Valley Steelhead Critical Habitat in the Delta

The proposed action components provided in Table 180 summarizes the action components and their effects on various PBFs of critical habitat in the Delta.

Table 180. Summary of probable change in physical or biological features of California Central Valley steelhead designated critical habitat in the Delta, relative to EXP3.

Action Component	Physical or Biological Feature Affected	Response
Water transfers	Freshwater rearing sites	(1) In-river flows that provide suitable water temperature conditions in the mainstem Sacramento River. (2) Flows that provide suitable dissolved oxygen conditions through improved mixing of water column and water surface-air interface. (3) Water quality sufficient to support primary and secondary productivity, benefitting forage base. (4) Insufficient conditions for successful holding and rearing habitat for juveniles in the south Delta due to water transfers resulting in increased exports.
Water transfers	Freshwater migratory corridor	Enhanced flows from water transfers can benefit migratory habitat for juveniles migrating downstream by decreasing travel times, increasing the length of riverine reaches, and muting downstream tidal effects. Increased flows can also stimulate upstream migration in the fall. Contribution of water transfers to increased exports may degrade migratory habitat in the South Delta.
North Bay Aqueduct/ Barker Slough Pumping Plant	Freshwater migratory corridor	Operations of North Bay Aqueduct/Barker Slough Pumping Plant may alter flow patterns affecting the migratory corridor PBF thereby inhibiting the mobility of juvenile listed salmonids and reducing their survival.
Delta Cross Channel Gate Closures (and Maintenance and Repair)	Freshwater migratory corridor	(1) Access to the interior Delta through open Delta Cross Channel gates reduces the survival of migrating juveniles, reducing the value of the main stem as a suitable migratory corridor. (2) Operations of the Delta Cross Channel gates can alter the extent of tidal influence in the river reaches downstream of the Delta Cross Channel location, delaying migration or re-routing juveniles into alternate migratory routes with lower survival. (3) Operations of the Delta Cross Channel gates reduces the upstream migratory function of the main stem Sacramento River to adults. (4) Open Delta Cross Channel gates allow entrainment into habitat exposed to the influence of the SWP and CVP export actions and reduces migratory habitat function.
CVP and SWP Export Facilities, and Old and Middle River Flow Management	Freshwater migratory corridor	Increased exports by the CVP and SWP Export facilities create hydrodynamic conditions in the channels of the South Delta that impede migration downstream to the ocean (reverse flows),
South Delta Agricultural Barriers	Freshwater rearing sites	Operation of the South Delta agricultural barriers will reduce flow velocities and increase water residence time within channels of the South Delta, degrading water quality and potentially increasing water temperatures.

Action Component	Physical or Biological Feature Affected	Response
South Delta Agricultural Barriers	Freshwater migratory corridor	Operation of the South Delta agricultural barriers create (1) physical barriers within the migratory corridor PBF; (2) decreases in water quality, including lower dissolved oxygen and suitable water temperatures that impair fish physiology; (3) creates habitat with excessive predation risk.
Delta Smelt Summer and Fall Habitat	Freshwater rearing sites	Release of additional water from upstream to augment Delta outflow will improve water quality, and enhance forage prey populations that support juvenile salmonid development.
Delta Smelt Summer and Fall Habitat	Freshwater migratory corridor	Release of additional water from upstream to augment Delta outflow will improve water quality and conditions supporting the mobility and survival of adult and juvenile salmonids.
Delta Smelt Summer and Fall Habitat	Estuarine areas	Release of upstream water will enhance (1) water quality, water quantity, and provide suitable salinity conditions supporting juvenile and adult salmonid physiological transitions; and (2) enhance forage prey that will support growth and maturation. Operations of the Suisun Marsh Salinity Control Gates will create temporary obstructions to free migration and potentially create predator habitat.

9.6.2.4.3. Assess Risk to California Central Valley Steelhead Critical Habitat in the Delta

Currently degraded estuarine habitat conditions that include altered hydrology in migration habitat and poor rearing habitats are expected to remain the same, with modest improvements or degradation under the proposed action. Tidal habitat restoration under the proposed action will likely improve some rearing and migratory habitat quality, but is unlikely to substantially offset all of the negative effects of operations and barriers on habitat associated with outflow and water quality. Under current usage practices, human population growth will place an increasing demand on limited water supplies, potentially exacerbating negative effects on freshwater and estuarine rearing and migratory habitats within the domain of CCV steelhead.

9.6.2.5. Stanislaus River

9.6.2.5.1. Status of California Central Valley Steelhead Critical Habitat in the Stanislaus River

California Central Valley steelhead critical habitat on the Stanislaus River has been designated up to Goodwin Dam. The PBFs of critical habitat for Stanislaus River CCV steelhead include freshwater spawning, freshwater rearing, and freshwater migration. Stanislaus River water temperatures are generally suitable for spawning and rearing; however, during the smolt emigration life stage (January through June), CCV steelhead may be exposed to water temperatures that may prohibit successfully completing transformation to the smolt stage. In addition, CCV steelhead spawning and rearing habitat on the Stanislaus River is affected by the limited occurrence of flows that are sufficient to carry out natural geomorphic processes. As such, sediment deposition on spawning habitats has decreased the availability of suitable spawning areas. Without strategic releases for geomorphic processes to manage fine sediment deposition in spawning gravels, spawning beds will be increasingly choked with sediment and

unsuitable for spawning. The relatively low and uniform releases in the Stanislaus River negatively affect rearing habitat by reducing habitat complexity and decreasing connectivity with flood plains, areas proven to be high quality rearing habitats in the California Central Valley (Sommer et al. 2005).

9.6.2.5.2. Project Effects on California Central Valley Steelhead Critical Habitat in the Stanislaus River

The factors affecting the current status of critical habitat for Stanislaus River CCV steelhead are all related to operations of the East Side Division of the CVP. Because operations of the East Side Division under the proposed action result in flow and temperature conditions generally consistent with past operations, the proposed action is expected to maintain the spawning, freshwater rearing, and freshwater migration corridors PBFs of critical habitat within the Stanislaus River, as follows:

- Freshwater rearing habitat for juveniles PBFs includes water quantity and floodplain connectivity to support juvenile growth and mobility and water quality and forage to support juvenile development. The proposed action shows slight decreases in instream rearing habitat in November through January but increases in the months of April and May. Overall, the proposed action will result in small decreases in instream rearing habitat and medium to large reductions in floodplain rearing habitat availability.

9.6.2.5.3. Assess Risk to California Central Valley Steelhead Critical Habitat in the Stanislaus River

Habitat within the Stanislaus River below Goodwin Dam is believed to be historically unsuitable for CCV steelhead spawning and rearing (Lindley et al. 2006). As a result, CCV steelhead habitat on the Stanislaus River must be maintained by releases from Goodwin Dam. Elevated summer rearing temperatures, minimum flows, and dissolved oxygen standards are expected to continue under the proposed action.

9.6.2.6. San Joaquin River

9.6.2.6.1. Status of California Central Valley Steelhead Critical Habitat in the San Joaquin River

California Central Valley steelhead critical habitat on the San Joaquin River has been designated up to the confluence with the Merced River, however, the action area extends only up to the confluence with the Stanislaus River. Therefore, consistent with the analysis of effects to CCV steelhead in the San Joaquin River, the analysis in this section is limited in geographic extent to the San Joaquin River from the confluence with the Stanislaus River downstream past Vernalis to approximately Mossdale. Effects to designated critical habitat for CCV steelhead downstream of Mossdale are discussed in the Effects of the Action on Critical Habitat, Bay-Delta Division section. The PBFs of critical habitat for CCV steelhead in the San Joaquin River include freshwater rearing and freshwater migration. California Central Valley steelhead rearing and migratory habitat on the San Joaquin River is affected by channelization and the limited occurrence of flows that are sufficient to carry out natural geomorphic processes, leading to low habitat complexity and lack of connectivity to side channels or other shallow water habitat.

9.6.2.6.2. Project Effects on California Central Valley Steelhead Critical Habitat in the San Joaquin River

Operations under the proposed action do not allow for overbank flow to maintain floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility. Lack of flow fluctuation and channel-forming flows has reduced habitat complexity, including undercut banks and side channels. Proposed operations will continue to degrade rearing habitat conditions. Under proposed operations, the freshwater migration corridors on this reach of the San Joaquin River will continue to require juvenile CCV steelhead to pass through a channelized river without the historical variety of habitats that allowed migrating salmonids to avoid high flows, avoid predators, and reach the ocean in a timely manner. California Central Valley steelhead will often navigate these freshwater migration corridors at times that may not be optimal with respect to water temperature. In drier year types, flows at Vernalis are projected to be lower in April–June during the primary out-migration period of CCV steelhead. Flows in January and February are higher in wetter year types. Water temperatures at Vernalis are most unsuitable for rearing in April and May and also unsuitable in March during drier years. Water temperatures at Vernalis are likely to be stressful to out-migrating juvenile CCV steelhead or even serve as a barrier to migration in May through September, and in April during drier years.

The freshwater migratory corridor PBFs are primarily a reflection of habitat connectivity and whether there are any barriers to migration, physical or otherwise (e.g., temperature). Under the proposed action, the freshwater migration corridors on the Stanislaus River will continue to require adult and juvenile CCV steelhead to pass water temperatures that may impair migration.

9.6.2.6.3. Assess Risk to California Central Valley Steelhead Critical Habitat in the San Joaquin River

Degraded critical habitat conditions include limited habitat complexity, unsuitable water temperatures in late spring and summer, and sub-optimal spring flows that are expected to continue under the proposed action. In summary, the conservation value of the freshwater rearing and migration PBFs has been, and will continue to be, relatively poor with the implementation of the proposed action.

9.6.3. Risk to California Central Valley Steelhead Critical Habitat at the Designation Level

Critical habitat for CCV steelhead in Clear Creek, the mainstem Sacramento River, the American River, and the Stanislaus River is highly degraded due to the effects of past and ongoing actions. Ongoing private, state, and federal actions and future non-federal actions are likely to continue to impair the function of PBFs and slow or limit the development of these features, with the exception of restoration actions that may counteract these effects to some degree. Climate change is expected to further degrade the suitability of habitats in the Central Valley through increased temperatures. However, the timing of CCV steelhead migration makes them less sensitive to these effects, and temperature management actions are expected to counteract or minimize these effects in the action area. Predicted climate change effects from increased frequency of drought, flood flows, overall drier conditions, and altered estuarine habitats are also expected to be somewhat reduced due to CVP water management over the life of the proposed action. While

Shasta Dam releases will limit downstream rearing habitat by increasing temperatures in the fall, actions in other tributaries will improve fall rearing habitat compared to current conditions. Proposed dam operations are expected to continue to limit natural hydrologic processes downstream. However, the proposed action is expected to increase the amount of spawning and rearing habitat available and improve hydrologic function compared to current conditions due to flow management, offsetting some of these continued effects. Proposed operations in the Delta will improve juvenile rearing habitat but may slightly reduce the quality of juvenile migratory corridors compared to current conditions. However, proposed changes are expected to improve Delta migratory corridor function for adult CCV steelhead.

While additional critical habitat exists in several tributaries outside the action area, the proposed action would affect key spawning reaches and a significant portion of migration and rearing habitat within the designated critical habitat for CCV steelhead. Although the current conditions of CCV steelhead critical habitat are significantly degraded, the habitat that remains in the Sacramento-San Joaquin River watershed and the Delta are considered to have high intrinsic value for species conservation, as they are critical to ongoing recovery efforts. The proposed action will offset some past effects of the CVP and SWP and improve others. NMFS expects the proposed ongoing operation of the CVP and SWP will result in diminished function of PBFs related to spawning, rearing, and migration within designated critical habitat in the action area. Implementing the proposed action is expected to improve habitat function within the action area, albeit modestly, such that, on the whole, the function of PBFs of critical habitat will not be significantly reduced. The proposed action is, therefore, not likely to appreciably diminish the value of designated critical habitat for the conservation of CCV steelhead.

9.7. Southern Distinct Population Segment of Green Sturgeon

9.7.1. Summary of the Environmental Baseline, Cumulative Effects, and Status of the Species

In this opinion, the effects of past CVP and SWP operations and the presence of existing structures are part of the environmental baseline. The effects of those actions have been analyzed through past consultation and contributed to the current condition of the species and critical habitat in the action area. Other past, present, and ongoing impacts of human and natural factors (including proposed federal projects that have already undergone ESA section 7 consultation) contributing to the current condition of the species and critical habitat in the action area are also included in the environmental baseline.

Southern DPS green sturgeon are exposed to numerous cumulative effects, such as unscreened water diversions, agricultural practices that impact water quality and riparian habitat, water contamination from municipal and agricultural sources, effects of urbanization, recreational and commercial fisheries, and other activities.

The sDPS of green sturgeon is at substantial risk of future population declines (National Marine Fisheries Service 2021a). The principal threat to green sturgeon in the sDPS is the reduction in available spawning habitat due to the construction of barriers on Central Valley rivers. The potential threats faced by sDPS green sturgeon include enhanced vulnerability due to the reduction of spawning habitat into one concentrated area on the Sacramento River, lack of empirical population data, vulnerability of long-term cold water supply for egg incubation and

larval survival, loss of juvenile sDPS green sturgeon due to entrainment at the CVP and SWP fish collection facilities in the South Delta and agricultural diversions within the Sacramento River and the Delta, alterations of food resources due to changes in the Sacramento River and Delta habitats, and exposure to various sources of contaminants throughout the basin to juvenile, sub-adult, and adult life stages.

9.7.2. Summary of the Proposed Action Effects to the Species

The effects analysis did not identify any high-magnitude stressors for sDPS green sturgeon. Some of the effects to sDPS green sturgeon from the proposed action include temperature impacts to incubating eggs and larvae in the Sacramento River, entrainment at Delta export facilities, and the installation of the South Delta Agricultural Barriers. Table 181 illustrates the affected life stages, primary stressors/effect pathways, and relevant management actions by CVP and SWP division or waterbody.

Table 181. Affected life stages, primary stressors/effect pathways, and relevant management actions by Central Valley Project/State Water Project division or waterbody.

Division/Water body	Seasonal Operations Period	Affected Life Stage	Summary of Primary Stressors and Effects of the Proposed Action	Relevant Management Actions
Sacramento River	Fall and Winter Operations	Adult migration	Shasta storage actions can reduce the frequency and magnitude of peak flows which impact the strength of migration cues	Fall and winter baseflows for Shasta Refill and Redd maintenance
Sacramento River	Spring Operations	Adult migration	Shasta storage actions can reduce the frequency and magnitude of peak flows which reduce the strength of migration cues	Affected by Shasta Framework based on Bin Objectives
Sacramento River	Summer Operations	Adult spawning and egg incubation	Water Temperature Management ● Colder than optimal water temperatures slow growth and development	Affected by Shasta Framework based on Bin Objectives
Delta	Summer and Fall Operations	Juvenile rearing and migration	Delta Cross Channel Operations ● Minimal impacts on survival rates. Individuals have extended rearing periods in the Delta (months to years)	Delta Cross Channel Closures, technical and policy team coordination during real-time operations, and adaptive management

Division/Water body	Seasonal Operations Period	Affected Life Stage	Summary of Primary Stressors and Effects of the Proposed Action	Relevant Management Actions
Delta	Winter and Spring Operations	Adult migration	Delta Cross Channel Gate Closures ● Gate closures occasionally impair upstream migration and cause migration delays	Delta Cross Channel Closures, technical and policy team coordination during real-time operations, and adaptive management
Delta	Winter and Spring Operations	Juvenile rearing and out-migration	Salvage and loss at state and federal Export facilities ● Infrequent salvage of individuals	OMR Flow Management, technical and policy team coordination during real-time operations, and adaptive management
Delta	Winter and Spring Operations	Juvenile rearing and out-migration	Agricultural Barrier Operations ● Passage impediments increase exposure to predation in May and June	Technical and policy team coordination

9.7.2.1. Adult Migration Cues

Shasta storage actions that occur during fall, winter and spring operations can reduce the frequency and magnitude of peak flows, which reduces the strength of migration cues. The primary actions are Fall and Winter base flows for Shasta Refill and Redd maintenance, but there is also an influence from the Shasta Framework based on Bin Objectives and relevant EOA storage objectives.

9.7.2.2. Water Temperature Management

The timing of Summer Cold Water Pool Management is such that it coincides with the peak of egg, larval, and juvenile sDPS green sturgeon presence in the Upper Sacramento River. Southern DPS green sturgeon spawn from April to July in the Sacramento River from Cottonwood Creek, just downstream of Balls Ferry, to Hamilton City. Sacramento River temperature management was rated as a medium threat to all life stages of sDPS green sturgeon (National Marine Fisheries Service 2018e), but conditions vary greatly across the distribution of spawning. In the upstream reaches of the spawning habitat, water releases from Keswick Dam to achieve temperatures of 53.5°F are cold enough to occasionally reduce the spawning and incubation success, while in the more downstream reaches, temperatures occasionally become too warm late in the spawning season.

Ambient water temperature modeled under the proposed action may exceed suitable levels (≥16°C or 61°F) during the critical egg fertilization and incubation period in the majority of years at the downstream extent of the putative spawning reach near Hamilton City (river mile 205). The suitability of downstream spawning areas is expected to be further restricted due to

increased water temperatures in critically dry water year types, which may become more frequent under different climate change scenarios.

9.7.2.3. Operation of the Delta Cross Channel Gates

Tagged sDPS green sturgeon are known to use the Delta Cross Channel while moving to and from upstream spawning sites (Israel and May 2010, as cited in National Marine Fisheries Service 2018e). The operation of the Delta Cross Channel gates influences survival and condition by providing false migration cues for juvenile and adult sturgeon. When the Delta Cross Channel gates are open, flows from the Sacramento River enter the interior Delta via the Mokelumne River system. Adults are likely to encounter open Delta Cross Channel gates during their summer and fall post-spawning out-migration. Juveniles rearing in the Delta may encounter open (mid-June through September), intermittently closed (October and November), or closed gates (December through mid-May). Reclamation proposes to continue to operate the Delta Cross Channel gates to reduce juvenile salmonid entrainment risk, and these closures also reduce the likelihood that sDPS green sturgeon will be killed or delayed by entrainment into the interior Delta.

9.7.2.4. Entrainment and Loss at the Delta Export Facilities

Similar to the effects on salmon and steelhead, Delta export actions occasionally cause mortality at the facilities and create migratory delays in response to altered hydrodynamics in channels of the South Delta. Migratory delays increase transit time and exposure to predators, poor water quality, and contaminants. Very few sDPS green sturgeon are observed or detected in the South Delta, and the effects of South Delta operations to sDPS green sturgeon are minimal. NMFS expects that the salmonid loss thresholds associated with OMR management will similarly reduce the export footprint for sDPS green sturgeon within the action area.

9.7.2.5. South Delta Agricultural Barriers

Installation of the South Delta agricultural barriers causes delayed migration and increased transit times, increasing mortality due to increased exposure to poor water quality and high water temperatures. NMFS acknowledges that delays at the South Delta agricultural barriers will likely increase predation on juvenile sDPS green sturgeon and result in reduced physiological condition. Based on the low numbers that have been salvaged at South Delta export facilities and other observations, few sDPS green sturgeon are likely to encounter the temporary rock weirs in the channels of Old River, Middle River, and Grant Line Canal.

9.7.2.6. Governance and Adaptive Management

The Governance element of the proposed action describes the proposed engagement of participating state and federal agencies, interested parties, and the public and how they will work together during implementation. Governance establishes the teams and principles subject to ongoing collaborative implementation and decision making, and identifies the processes for working together and elevating matters. Governance is important for ensuring implementation as described in the proposed action, including the complicated interface between real-time operations and the ongoing technical and management discussions that inform operations and species protections.

The proposed action also includes an AMP as a structured, iterative decision-making process when confronted with uncertainty. Adaptive management emphasizes learning through management where knowledge is incomplete and provides a process for building knowledge through monitoring and science, reducing uncertainty, and improving management over time in a goal-oriented and structured way. The AMP and related special studies include over 20 actions. While none of them target sDPS green sturgeon directly, by reducing knowledge gaps and uncertainty, they should be expected to improve management of the other listed species at some level, and indirectly also sDPS green sturgeon, and would be expected to inform actions that affect species risk.

9.7.2.7. Programmatic Actions

The opinion includes certain action components that were analyzed as framework programmatic actions that establish a framework for the development of future actions that would be authorized, funded, or carried out at a later time, and any take of a listed species would not occur unless and until those future actions are authorized, funded, or carried out and subject to further ESA section 7 consultation. We analyzed the effects of those actions qualitatively to understand how they might be carried forward in the context of water operations. The following framework programmatic actions are considered in this opinion:

- The Sites Reservoir Project: Adverse and beneficial effects to listed species and designated critical habitat. A broad suite of potential effects to individuals and PBFs of designated critical habitat are proposed to be minimized or avoided through established guiding principles, best management practices, adaptive management strategies, and monitoring and compensatory mitigation strategies. Project components include bypass and pulse flow criteria, monitor and mitigate the effects of diversions, habitat restoration, and use of the best available science to develop and implement operations plans.
- The Delta Conveyance Project: Adverse and beneficial effects to listed species and designated critical habitat. A broad suite of potential effects to individuals and PBFs of designated critical habitat are proposed to be minimized or avoided through established guiding principles, best management practices, adaptive management strategies, and monitoring and compensatory mitigation strategies. Project components include bypass and pulse flow criteria, monitor and mitigate the effects of diversions, habitat restoration, and use of the best available science to develop and implement operations plans.
- Spring Outflow - Post-Adoption of VAs: This action is expected to result in improved flow conditions and reduced entrainment for listed species in the Delta during April and May and improved survival over baseline for rearing and migration. These responses are consistent with the objectives of the long-term operations of the CVP and SWP to implement actions that reduce entrainment and improve survival through the Delta. These responses would mostly affect juvenile fish in particular, as they are most susceptible to entrainment and flow-related survival. There may also be some responses to juvenile rearing and survival during spring months on the Sacramento and American rivers during certain water year types. Risks to listed species are low.
- Drought Response (i.e., Drought Toolkit): The Drought Response action includes components designed to avoid or mitigate the effects of drought. A drought planning team will evaluate the need for drought actions annually and propose them on a case-by-case basis. Given the framework-level programmatic nature of this action, it is possible to

estimate the specific impacts but the overall objective is to consider and implement actions that avoid or mitigate drought-related consequences to listed species and their critical habitat.

- Monitoring: Many ongoing monitoring programs that inform operational actions and effects are currently under existing and separate ESA section 7 consultations and section 10(a)(1)(A) permits and considered in the Environmental Baseline section of this opinion. Potential future changes to monitoring programs associated with the operation of the CVP and SWP will be addressed in separate ESA section 7 consultations that are tiered to the consultation. Subsequent changes to existing monitoring programs would be coordinated and included in future consultations of the LTO of the CVP and SWP to allow for a more uniform analysis and improved accounting of incidental take coverage associated with the operation of the CVP and SWP.
- Tidal Habitat Restoration: Tidal habitat restoration will result in near-term impacts to aquatic and riparian habitat leading to lethal and sublethal impacts to listed species, but the risks to individuals will be avoided, minimized and mitigated through long-established best management practices. Post-construction habitat conditions will benefit the growth and survival of listed species and improve the conservation value of critical habitat.
- Adaptive Management and Special Studies: The Adaptive Management Program will utilize decision support tools such as structured decision-making to improve future management decisions to improve the operations of the CVP and SWP for project purposes. Most of the actions will improve the are intended to improve the capacity and precision of the projects to protect listed species.

9.7.3. Climate Change Considerations

In the Sacramento River, the upstream extent of the spawning range for sDPS green sturgeon lies somewhere below ACID Dam (river mile 298), as that dam and associated fish ladder presumably impede passage for sDPS green sturgeon in the Sacramento River. It is uncertain if sDPS green sturgeon spawning occurs in cooler water reaches of the Upper Sacramento River near ACID Dam, but this habitat could allow spawning to shift upstream in response to climate change effects.

9.7.4. Risk to Green Sturgeon at the Southern Distinct Population Segment Level

Given that the entire sDPS green sturgeon is represented by a single population, the discussion points above apply equally to both the population-level analysis and that of the sDPS as a whole. Although no specific VSP criteria have been developed for sDPS green sturgeon, we consider the effects of the proposed action and risk to the species in the context of adult abundance, productivity, diversity, spatial structure, and habitat capacity.

Southern DPS green sturgeon are known to range through the San Francisco Bay estuary, the Delta, and the Sacramento, Feather, and Yuba rivers. In summary, the available information indicates that the spatial structure of sDPS green sturgeon is composed of a single, independent population, which principally spawns in the mainstem Sacramento River and also breeds opportunistically in the Feather River and Yuba River. Concentration of adults in a very few select spawning locations makes the species highly vulnerable to poaching and catastrophic

events. The apparent extirpation from upstream spawning reaches of the San Joaquin River narrows the habitat usage by the species, leaving little buffer to impacts to the species.

NMFS expects that the effects of the proposed action on abundance are likely to be low. The elements of the proposed action most likely to reduce the abundance of the sDPS population are related to temperatures that affect spawning and early rearing, routing effects at the Delta Cross Channel, entrainment at Delta export facilities, and installation of South Delta agricultural barriers. Effects related to water exports in the South Delta and salvage records indicate that only low numbers of sDPS green sturgeon are likely to be entrained at these facilities.

Temperatures in the upper reach of the Sacramento River below the ACID Dam are likely to be below the optimal range for sDPS green sturgeon egg incubation and juvenile rearing due to cold water releases from Shasta Reservoir to protect SR winter-run Chinook salmon. This may reduce the productivity of spawning sDPS green sturgeon in the upper reaches of the Sacramento River closer to Keswick Reservoir, but productivity is likely higher further downstream. The overall impact of operations on sDPS green sturgeon production is not precisely known.

The installation of the South Delta agricultural barriers could affect the ability of sturgeon to migrate within estuarine habitats. The proposed action will not affect the species' ability to migrate to upstream spawning habitats. The existence of Shasta, Keswick, and ACID dams, which limit access to historical spawning areas in the Sacramento River, are part of the environmental baseline for this consultation.

Overall, the proposed action is not expected to exert any additional selective pressures on sDPS green sturgeon that would affect the diversity parameter. Given the higher temperature tolerances of the early life stage of sDPS green sturgeon compared to salmonids, appropriate conditions for spawning and incubation are present year-round in accessible reaches of the Sacramento River. This allows for the potential for multiple spawning runs of sDPS green sturgeon in the Sacramento River in most years.

The proposed action does not include any specific measure to protect sDPS green sturgeon from the effects of climate change. Existing water temperatures are likely to be suboptimal for egg incubation and juvenile growth in years in the Upper Sacramento River; however, these cold conditions provide a buffer against the effects of climate change by allowing for an upstream shift in spawning.

The proposed action includes measures that may partially offset the medium to low ranked stressors caused by the proposed action. Supplementing spawning gravels for salmonids could also enhance habitat for sDPS green sturgeon if provided in areas where they overlap. Altered flow was considered a medium to low threat in the recovery plan for sDPS green sturgeon (National Marine Fisheries Service 2018e). Therefore, the proposed Spring Pulse Flow action component is expected to provide a beneficial effect on adult upstream migration. Several elements of the proposed action align with actions identified in the recovery plan for the sDPS green sturgeon (National Marine Fisheries Service 2018e), such as developing flow and temperature targets that support successful spawning, incubation and rearing habitat below impoundments.

The proposed action also does not impede implementation of other key elements of the recovery plan, such as improving passage and water quality conditions in the Yuba and Feather rivers and reducing non-point source contaminants in the Delta. Implementation of the proposed action is, therefore, not creating conditions that would preclude recovery of sDPS green sturgeon in the future.

After considering its current rangewide status, the environmental baseline within the action area, the effects of the proposed action, the effects of other activities, and cumulative effects, NMFS concludes that the proposed action is not likely to appreciably reduce the likelihood of both the survival and recovery of the sDPS green sturgeon.

9.8. Southern Distinct Population Segment of Green Sturgeon Effects on Designated Critical Habitat

9.8.1. Summary of the Status of Designated Critical Habitat

The PBFs essential for the conservation of listed sDPS green sturgeon within the action area include (1) food resources, (2) substrate type or size, (3) water flow, (4) water quality, (5) migratory corridor, (5) water depth, and (6) sediment quality.

Many of the PBFs of sDPS green sturgeon designated critical habitat are currently degraded or impaired and provide limited high-quality habitat. Features that lessen the quality of migratory corridors and rearing habitat for juveniles include unscreened or inadequately screened diversions, altered flows in the Delta, and the presence of contaminants in sediment. Although the current conditions of sDPS green sturgeon critical habitat are significantly degraded, the spawning habitat, migratory corridors, and rearing habitat that remain in both the Sacramento/San Joaquin river watersheds and the Delta are considered to have high intrinsic value for the conservation of the species.

9.8.2. Summary of Proposed Action Effects on Designated Critical Habitat

Similar to the effects analysis for the species, the effects analysis did not identify any high-magnitude stressors on the critical habitat, but did identify several medium-ranked stressors, including those related to Shasta spring and summer operations, the Delta Cross Channel operation, and Delta exports. Beneficial actions include habitat restoration, spring pulse flows, and spring outflow. Medium-ranked stressors on the PBFs of designated critical habitat affected by the proposed action are described below.

9.8.2.1. Water Flow

The spring pulse flows in the Sacramento River should improve the function of the freshwater migratory corridor during spring months compared to current conditions. The water flow PBF of sDPS green sturgeon critical habitat is also related to the food resources, sediment quality, and depth PBFs because water flow can determine access to the quantity and quality of the other PBFs in the freshwater rearing habitat. Changes to floodplain inundation is a metric used to measure the overall quantity of riparian habitat and the relative access to the PBFs of food resources, sediment quality, and depth. Results of floodplain inundation analyses for Fremont Weir spill show a decrease in the monthly flow on to the Yolo Bypass for the proposed action

compared to the baseline from December to March (Figure F.2.2-10-1 in U.S. Bureau of Reclamation 2023-2024) with more pronounced effects in above normal, below normal and dry years, particularly in December. This is expected to provide a decrease in freshwater rearing habitat for juvenile sDPS green sturgeon.

Operations of the CVP and SWP export facilities alter the flows in the channels of the South Delta, degrading the functioning of the channels as a migratory corridor and can affect the ability of emigrating fish to reach the western Delta and the Pacific Ocean. Effects of the altered flow conditions increases the exposure to entrainment into the export facilities and could delay migration and expose individuals to poor rearing habitat. Southern DPS green sturgeon may be exposed to these effects for the duration of the proposed action with effects increasing in magnitude the closer to the export facilities the fish are located.

Based on the May to October timing of larval and juvenile occurrence in the Sacramento River at Glenn Colusa Irrigation District (Poytress et al. 2015), the predicted range of water temperatures in the Sacramento River for the proposed action is expected to have a beneficial effect on the water quality critical habitat PBF used by juveniles for rearing. See Table 182 for proposed action effects to critical habitat in the Sacramento River.

9.8.2.2. Migratory Corridor

The overall effect on the quality of critical habitat is partially offset by the salmon and steelhead loss thresholds associated with OMR management, which will ensure flows, and therefore migratory corridor function, is not further impaired in this reach. Delta Cross Channel gate operations and the operation of the South Delta agricultural barriers have the potential to delay movement and migratory behavior in the channels of the South Delta. Juvenile and adult sDPS green sturgeon may be trapped behind the barriers after construction/operation for varying periods of time. Changes to the Delta Cross Channel operations may increase the potential for migratory delays for sDPS green sturgeon but may reduce the routing of juveniles into the interior Delta. See Table 183 for proposed action effects to critical habitat in the Delta.

Table 182. Southern Distinct Population Segment of green sturgeon summary of effects of the action on critical habitat in the Sacramento River (from Inks Creek to the Delta) compared to EXP3.

Life Stage	Action Component	Physical and Biological Features (PBFs) Affected	Response and Rationale of Effect
Habitat for Spawning Adults, Incubation of Eggs, and Rearing for Larvae sDPS green sturgeon PBFs	Spring and Summer Operations	Water Quality Water Flow Substrate Type or Size	The flow reductions in March through May, which artificially detain high natural flows, can be expected to limit access to food-rich floodplain habitat and reduce survival.

Life Stage	Action Component	Physical and Biological Features (PBFs) Affected	Response and Rationale of Effect
Freshwater Rearing Habitat for Juveniles and Subadults sDPS green sturgeon PBFs	Summer and Fall Operations	Water Quality Water Flow Food Resources Sediment Quality Depth	Colder than optimal water temperatures may slow growth and development.
Freshwater Migratory Corridor PBFs for Out-migrating Juveniles and Spawning Adults	Year-Round Operations	Migratory Corridor Sediment Quality Depth	May influence fish travel time and migration routing

Table 183. Summary of affected physical or biological features of the Southern Distinct Population Segment of green sturgeon designated critical habitat in the Delta.

Action Component	Physical or Biological Feature Affected	Response
Water transfers	Freshwater Riverine Habitat	(1) Additional in-river flow may improve water quality conditions (i.e., temperatures and dissolved oxygen) in the mainstem Sacramento River. (2) Improved water flow may improve migratory corridor conditions. (3) Improved water quality in the fall may improve primary and secondary productivity, benefitting food resources.
North Bay Aqueduct/Barker Slough Pumping Plant	Freshwater Riverine Habitat	Operations of North Bay Aqueduct/Barker Slough Pumping Plant may delay movements of juveniles due to alterations to flow patterns created by the export of water and thereby impeding the mobility of juvenile green sturgeon.
Delta Cross Channel Gate Closures (and Maintenance and Repair)	Freshwater Riverine Habitat	(1) Access to the interior Delta through open Delta Cross Channel gates alters the function of the mainstem Sacramento River as a suitable migratory corridor to the western Delta. (2) Operations of the Delta Cross Channel gates can alter the extent of tidal influence in the river reaches downstream of the Delta Cross Channel location, delaying migration or re-routing juveniles into alternate migratory routes with lower habitat quality. (3) Operations of the Delta Cross Channel gates reduces the upstream migratory function of the mainstem Sacramento River to adults. (4) Open Delta Cross Channel gates allow entrainment into habitat exposed to the influence of the SWP and CVP export actions and reduces migratory habitat function.

Action Component	Physical or Biological Feature Affected	Response
CVP and SWP Export Facilities, and Old and Middle River Flow Management	Freshwater Riverine Habitat	Increased exports by the CVP and SWP export facilities create hydrodynamic conditions in the channels of the South Delta that impede or alter green sturgeon movements in the region's migratory corridors (reverse flows).
South Delta Agricultural Barriers	Freshwater Riverine Habitat	Operations of the South Delta agricultural barriers will reduce flow velocities and increase water residence time within channels of the South Delta, degrading water quality and potentially increasing water temperatures. Construction of the South Delta agricultural barriers creates barriers to the movements of adult and juvenile green sturgeon within the South Delta waterways containing the barriers.
Delta Smelt Summer and Fall Habitat	Freshwater Riverine Habitat	Releases of additional water from upstream to augment Delta outflow will improve water quality and enhance forage prey populations that support juvenile and adult green sturgeon. Releases of additional water from upstream to augment Delta outflow will improve water flow supporting the mobility and survival of adult and juvenile green sturgeon.
Delta Smelt Summer and Fall Habitat	Estuarine areas	Release of upstream water will (1) enhance water quality and water quantity, and (2) enhance juvenile and adult forage prey that will support growth and maturation. Operations of the Suisun Marsh Salinity Control Gates will create temporary obstructions to free migration.

9.8.3. Risk to Critical Habitat at the Designation Level

The negative effects of the proposed action on freshwater migratory pathways in the environmental baseline for this consultation (i.e., the existence of Shasta, Keswick, and ACID dams) will continue under the proposed action. Other barriers are likely to be reduced by implementing more conservative thresholds for gate closure at the Delta Cross Channel and South Delta export facilities. Although flows have been altered by CVP and SWP operations and altered water flow was ranked as a medium to low threat in the recovery plan (National Marine Fisheries Service 2018e), NMFS has not developed flow targets to support sDPS green sturgeon spawning and rearing. With the inclusion of the Spring Pulse Flow action, flows in the Sacramento River will generally be similar to current conditions.

While the PBFs in the designated freshwater riverine and estuarine habitat are degraded under baseline conditions, they still function in providing access from the upper river habitat to the marine environment. The proposed action will offset some past effects of the CVP and SWP and improve others compared to current conditions. NMFS expects the proposed ongoing operation of the CVP and SWP will result in diminished function of PBFs related to rearing and migration

within designated critical habitat in the action area. The proposed action will result in increased habitat with suitable temperatures for egg incubation and larvae rearing, but will decrease habitat for migration through less floodplain inundation. On the whole, the function of PBFs of critical habitat will not be significantly reduced. The proposed action is, therefore, not likely to appreciably diminish the value of the critical habitat for the conservation of sDPS green sturgeon.

9.9. Southern Resident Killer Whale Effects on the Species

9.9.1. Summary of the Status of Southern Resident Killer Whales

The SRKW DPS was listed as endangered under the ESA in 2005 (70 FR 69903). The SRKW DPS is at a high risk of extinction, primarily from low abundance and impaired survival and fecundity, especially in recent years. Major threats to this species include limitations in available preferred prey (Chinook salmon), vessel and sound impacts, contaminants, inbreeding, and climate change. Recent updates to population viability analyses suggest a continued downward trend in population growth projected over the next 50 years (National Marine Fisheries Service 2016f). This downward trend is in part due to the changing age and sex structure of the population, but also related to the relatively low fecundity rate observed over the period from 2011 to 2016 (National Marine Fisheries Service 2016f). Recent analyses have concluded the effects of prey abundance on fecundity and survival have a large impact on the potential population growth rate (Lacy et al. 2017, Williams et al. 2024).

Diet data indicate that Chinook salmon is the primary prey for SRKWs year-round, presumably because of Chinook salmon's large size, high fat and energy content, and year-round occurrence in the whales' geographic range. Analysis of prey remains and fecal samples collected during the winter and spring in coastal waters indicate that Chinook salmon from the Columbia River, California Central Valley, Puget Sound, and Fraser River Chinook salmon comprise over 90 percent of the whales' coastal Chinook salmon diet during that period (Hanson et al. 2021). Changing ocean conditions driven by climate change may influence the ocean survival of Chinook salmon and other Pacific salmon, further affecting the prey available to SRKWs. The available information suggests that large changes in overall Chinook salmon prey abundance (i.e., at least a 15-percent overall increase, as estimated by Lacy et al. [2017]) are necessary for SRKW to reach population growth recovery targets.

9.9.2. Summary of Proposed Action Effects

The proposed action affects the survival of all life stages of Chinook salmon in the Central Valley, and thus the number of Chinook salmon that enter the Pacific Ocean and become available as prey for SRKWs. The proposed action results in stressors to Chinook salmon that can affect their survival and recruitment potential to the ocean. Some key stressors include increased water temperatures that affect the survival of all life stages, reduced juvenile survival from routing into the Delta, and flow management resulting in redd dewatering and juvenile stranding. The proposed action also includes measures that are expected to improve the survival and abundance of Chinook salmon in the Central Valley and their ocean recruitment. These include pulse flows during the spring which could improve conditions for rearing and migration along the Sacramento River, Clear Creek, and through the Delta.

It is likely that SRKWs will continue to be exposed to and affected by reductions and limitations in the abundance of Chinook salmon available as prey as a result of the proposed action. Our analysis determined that this exposure would likely lead to changes in the foraging behavior and success of SRKWs in the action area and increased risks of nutritional stress for individual SRKWs. However, the magnitude of this adverse effect is expected to be relatively small. Compared to the modeled NAA scenario, the proposed action is estimated to result in a change of less than 1 percent in overall abundance of total Chinook salmon available as prey to SRKWs, largely due to the changes in productivity expected for the dominant fall-run Chinook salmon populations. We recognize that these estimates could not account for all stressors on all Chinook salmon populations affected by the proposed action and that the conditions for CV Chinook salmon as a result of the proposed action could be quite variable. Our assessment indicates a median reduction of 0.38 percent (~1,500 adult Chinook salmon) annually for at least the first 2 years, with a potential range in change in abundance from -3.63 percent (~14,300 adults) to +4.34 percent (~17,200 adults) annually, followed by a median increase of 0.011 percent (~440 adult Chinook salmon) annually for any remaining years of the proposed action without VAs, with a potential range in change in abundance from -4.11 percent (~16,200 adults) to +4.38 percent (~17,300 adults). We also recognize that, in years when prey is reduced as a result of the proposed action, the actual prey reduction experienced in waters where CV Chinook salmon are found, and at the time of year SRKWs prey on them, is likely greater than this general quantitative median estimate. However, the magnitude of reduction is still expected to be small.

9.9.3. Summary of Risk to Southern Resident Killer Whale Distinct Population Segment

Overall, the proposed action will result in adverse effects to adult CV Chinook salmon available to SRKWs as prey in the ocean. To contextualize the results of the quantitative analyses summarized above, we also considered the temporal overlap of the expected reduction in CV Chinook salmon available as prey under the proposed action with feeding SRKW. Central Valley Chinook salmon have been observed in the SRKW diet in the winter and spring months when SRKWs exhibit poorer body condition, particularly younger individuals (Fearnbach et al. 2019, Hanson et al. 2021). During these months, the K and L pods, in particular, spend a greater amount of time in coastal waters where they are likely to be affected by reductions in CV Chinook salmon. As demonstrated in the Status of the Species section, the number of reproductive-aged females in the K and L pods has steadily declined over time, signifying a substantial risk of future population declines.

Numerous additional factors are also affecting Chinook salmon and the availability of prey in the action area, including predation by other marine mammals and recreational and commercial harvest of Chinook salmon in the ocean. NMFS completed consultations on the operation of the Klamath River water project from 2019 to 2024 and from 2024 to 2029 (National Marine Fisheries Service 2019a, 2024c). Both of these opinions concluded that the proposed action would reduce the amount of Klamath River fall-run Chinook salmon available as prey for SRKWs off the coast of California and Oregon, in areas overlapping with the action area for this proposed action, through at least 2033 (National Marine Fisheries Service 2019a, 2024c). As described previously, droughts have also significantly affected CV Chinook salmon productivity and abundance. Periodic and prolonged droughts are typical in California, but we expect that, given the climate change scenarios discussed in this opinion, droughts may occur more frequently in the future. To address this, Reclamation has developed a number of proposed action

components to address drought and dry year conditions. We expect these to increase salmon population resiliency in future drought and dry year conditions. These, in turn, should help stabilize or improve prey availability for SRKW in the ocean under the predicted effects of climate change.

Some actions have been taken in recent years to increase prey availability for SRKWs in the action area. One of the domestic actions associated with the 2019–2028 PST Agreement was to provide federal funding annually for increased hatchery production of SRKW prey. These additional releases are contributing towards the goal of increasing adult Chinook salmon abundance by 4 to 5 percent in coastal areas during the winter, and inland (Salish Sea) areas during the summer (National Marine Fisheries Service 2024d). In 2021, NMFS consulted on the removal of four dams on the mainstem Klamath and associated activities, such as infrastructure modifications, removal, and reservoir drawdown, that impact Chinook salmon habitat (National Marine Fisheries Service 2021g). While temporary impacts to Chinook salmon are expected short-term habitat degradation, long-term benefits to the SRKW prey base in areas overlapping with the action area of this proposed action are expected due to increased natural-origin Chinook salmon production and survival.

Overall, the productivity of CV Chinook salmon, especially the dominant fall-run population, appears to be decreasing over time. In general, the factors affecting non-listed Chinook salmon (fall-run and late fall-run) in the freshwater environment in the Central Valley are very similar to what is discussed for ESA-listed Chinook salmon. Therefore, the decline of fall-run Chinook salmon is likely a result of many important factors, including the ongoing effects of CVP and SWP operations affecting the survival and productivity of all CV Chinook salmon populations. The declining trend in Chinook salmon productivity in the Central Valley is of concern to the long-term outlook for available prey resources for SRKWs. Currently, the overall productivity of this system depends heavily on modified hatchery release practices to minimize impacts from the proposed action and other factors in the Central Valley. The proposed action would add further, albeit slight, reductions in adult ESA-listed and non-ESA-listed Chinook salmon available as prey to SRKWs to this declining trend. However, after considering its current rangewide status, the environmental baseline within the action area, the effects of the proposed action, and cumulative effects, NMFS concludes that the proposed action is not likely to appreciably reduce the likelihood of both the survival and recovery of the SRKW DPS.

9.10. Southern Resident Killer Whale Effects on Critical Habitat

9.10.1. Summary of the Status of Designated Critical Habitat

Critical habitat includes approximately 2,560 square miles of inland waters of Washington and 15,910 square miles of coastal waters off of Washington, Oregon and California. The critical habitat designation for SRKWs identifies three PBFs essential to their conservation: (1) water quality, (2) prey quantity, quality, and availability, and (3) passage conditions. The section on Effects of the Action on Southern Resident Killer Whales considers pathways of effects related to prey. Therefore, this analysis draws heavily on the previous assessment of impacts to the whales when considering effects on the habitat features.

9.10.2. Summary of Proposed Action Effects on Designated Critical Habitat

The critical habitat feature related to prey includes prey quantity, quality, and availability, and this analysis draws on the analysis of the effects on prey to the whales themselves. While CV Chinook salmon have been documented in prey samples in the inland portion of SRKW designated critical habitat, they were only observed in approximately 5 percent of the samples taken in that region. Therefore, we expect the greatest impacts of the proposed action on critical habitat to occur in the coastal portion of the range, where CV Chinook salmon were observed in 20 percent of the prey samples in the winter and spring months. As described in the Effects to Southern Resident Killer Whale Critical Habitat section, we expect the greatest effects to SRKW critical habitat due to the proposed action to occur in Areas 4 and 6 of their designated coastal critical habitat.

9.10.3. Summary of Risk to Designated Critical Habitat

The effects of the proposed action on SRKW critical habitat add a measurable but small adverse effect to the existing conditions, considering with it the environmental baseline within the action area and cumulative effects. On the whole, the function of PBFs of critical habitat will not be significantly reduced. The proposed action is, therefore, not likely to appreciably diminish the value of the critical habitat for the conservation of SRKWs.

10. CONCLUSION

After reviewing and analyzing the current status of the listed species and critical habitats, the environmental baseline within the action area, the effects of the proposed action, the effects of other activities caused by the proposed action, and the cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, California Central Valley steelhead, Southern distinct population segment of North American green sturgeon, or Southern Resident killer whales, or destroy or adversely modify their designated critical habitats.

11. INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. "Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct. "Harm" is further defined by regulation to include significant habitat modification or degradation that actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding, or sheltering (50 CFR 222.102). "Harass" is further defined by guidance as to "create the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering." "Incidental take" is defined by regulation as takings that result from, but are not the purpose of, carrying out an otherwise lawful activity conducted by the federal agency or applicant (50 CFR 402.02). Section 7(b)(4) and section 7(o)(2) of the ESA provide that taking that is incidental to an otherwise lawful agency action is not considered to be prohibited taking under the ESA if that action is performed in compliance with the terms and conditions of this incidental take statement.

An incidental take statement is not required for a framework-level programmatic action component, i.e., an action "that approves a framework for the development of future action(s) that are authorized, funded, or carried out at a later time, and any take of a listed species would not occur unless and until those future action(s) are authorized, funded, or carried out and subject to further ESA section 7 consultation" (50 CFR 402.02; 50 CFR 402.14).

For a mixed programmatic action, an incidental take statement is required only for those programmatic actions that are reasonably certain to cause take and are not subject to further ESA section 7 consultation (50 CFR 402.14). A mixed programmatic action is defined as, "for the purposes of an incidental take statement, a federal action that approves action(s) that will not be subject to further ESA section 7 consultation, and also approves a framework for the development of future action(s) that are authorized, funded, or carried out at a later time and any take of a listed species would not occur unless and until those future action(s) are authorized, funded, or carried out and subject to further ESA section 7 consultation" (50 CFR 402).

If an action agency designs a mixed programmatic action that approves a framework for the development of future action(s) that are authorized, funded, or carried out at a later time and provides adequate information to inform the development of a biological opinion related to future actions implemented under the program that are not subject to further ESA section 7 consultation, NMFS will include an incidental take statement related to such programmatic action if it determines that the action is reasonably certain to cause incidental take of listed species.

The long-term operation of the CVP and SWP is a mixed programmatic action that includes: (1) a framework for the development of future actions, and (2) actions that are not subject to further approvals. This incidental take statement is applicable to all activities related to the long-term operations of the CVP and SWP, as described in Reclamation's BA (2023-2024), including operations of dams, reservoirs, power plants, pumping facilities, and fish salvage facilities; administration of water contracts; and research and monitoring activities for which Reclamation provided adequate information regarding the action, if the action is reasonably certain to occur, and if the action would result in incidental take of listed species. This incidental take statement does not include framework programmatic action components of the proposed action where information was not sufficient to determine take of listed species. The incidental take exemptions provided for in this incidental take statement are effective only upon Reclamation's issuance of the ROD.

The waterways of the Central Valley are a complex and highly altered ecosystem, and our understanding of how ESA-listed fish and their habitats are affected by water operations versus other closely related or unrelated stressors and activities improves annually with the development and emergence of new science, monitoring and approaches to water management.

11.1. Administration of Water Supply Contracts

This consultation addresses the LTO of the CVP and SWP as described in the proposed action, including the overall impacts of the total discretionary volume of water stored, released, diverted, and conveyed in accordance with existing water contracts and agreements, including water service and repayment contracts, settlement contracts, exchange contracts, and refuge deliveries, consistent with water rights and applicable laws and regulations. Coverage includes delivery of non-discretionary quantities of water to any contractor entitled to such deliveries, including

diversions in accordance with the SRS Contracts and actions by SRSCs to support the Shasta Framework. The volume of water delivered may be reduced from full contract amounts, consistent with the terms of individual contracts. In addition, incidental take from the specific timing and operations associated with the movement of the water to be transferred (but not making water available for transfer), as described in Section 3.7.11 of Reclamation's BA (2023-2024), is included in CVP and SWP operations for this consultation.

11.2. Stressors Resulting in Incidental Take of Listed Species

The proposed action creates a variety of stressors, which are listed and described in the Effects of the Action section of this opinion. Of those stressors, the following are expected to result in the incidental take of listed species:

- **Passage Impediments/Barriers** through operation of the Delta Cross Channel gates and installation of agricultural barriers. Passage impediments/barrier stressors are expected to include modified routing, modified travel/migration time, and limited habitat, resulting in sublethal or lethal effects.
- **Water Temperature** in the Upper Sacramento River, American River, Stanislaus River, and Clear Creek. Due to the location of monitoring points, temperature-based take surrogates may vary based on the location of available gaging stations. For example, the CCR gage used for the SR winter-run Chinook salmon spawning compliance point is located directly within the spawning habitat on the Sacramento River. The American River's gage at Watt Avenue is at the downstream extent of suitable summer rearing habitat for CCV steelhead. On Clear Creek, the available gauging site is at Igo, and thus, daily average water temperatures at Igo are used to develop the surrogate. We do not imply that temperature tolerance varies based on watershed or river system (although it may), only that gages that provide reliable surrogates for temperature conditions may vary based on gage site location in relation to spawning locations.
- **Water Flow** within the Sacramento River, Clear Creek, American River, Stanislaus River, interior Delta, and Delta outflow. Flow condition stressors include redd dewatering, redd scour, isolation and stranding, limited habitat, and travel/migration time.
- **Entrainment or Impingement** primarily at the Delta Cross Channel gates, the state and federal pumping facilities in the South Delta, the Contra Costa Water District/Rock Slough diversion intakes, and the North Bay Aqueduct intake. Entrainment stressors are expected to include modified routing, modified travel/migration time, and exposure to degraded habitat.

11.3. Amount or Extent of Incidental Take

The ESA section 7 regulations require NMFS to specify the impact of any incidental take of endangered or threatened species; that is, the amount or extent of such incidental taking on the species (50 CFR 402.14). Generally, the amount or extent of incidental take is expressed as the number of individuals that are expected to be taken by the proposed action. A surrogate (e.g., similarly affected species or habitat or ecological conditions) may be used to express the amount or extent of anticipated incidental take provided that the biological opinion or incidental take statement describes the causal link between the surrogate and incidental take of the listed species, explains why it is not practical to express the amount or extent of anticipated incidental take or to monitor take-related impacts in terms of individuals of the listed species, and sets a

clear standard for quantifying and monitoring each surrogate and determining when the level of anticipated incidental take has been exceeded (50 CFR 402.14 (i)(1)(i), which would require reinitiation of consultation

During consultation, as described above in the opinion, NMFS determined incidental take of endangered SR winter-run Chinook salmon, threatened CV spring-run Chinook salmon, threatened CCV steelhead, threatened sDPS green sturgeon, and endangered SRKW will occur as a result of the LTO of the CVP and SWP.

The proposed action is a totality of many activities that comprise the LTO of the CVP and SWP. Some of the effects can be isolated to a single action. In other cases, impacts to individuals of listed species cannot be traced solely to a single component of the action but may be a result of compounding effects of several individual activities. The incidental take of ESA-listed species is described below based on Reclamation's division structure as evaluated in the opinion and includes all incidental take expected from the proposed action except activities for which the effects were identified to require separate consultation.

We identify the amount or extent of incidental take by listed species, life history stage, stressor, and location within the action area. If it was not practical to express the amount or extent of anticipated incidental take or to monitor take-related impacts in terms of individuals of the listed species as a result of the proposed action, we determined the extent of incidental take by designating an ecological surrogate consistent with 50 CFR 402.14.

11.3.1. Upper Sacramento River (Shasta and Sacramento) Division

Shasta Dam operations have consequences for the entire system. Operating Shasta Dam (and related facilities) involves actions that impact water temperature, flow, and water quality. The Shasta Framework and the Shasta Cold Water Pool Management Plan components of the proposed action are the primary mechanisms to provide cold water to listed salmonids in this Division. Take of listed species will result from the implementation of these components of the proposed action.

Adherence to the annual Shasta Framework and the Shasta Cold Water Pool Management Plan, as defined in the proposed action, is expected to result in varying levels of take across years. Implementation of the Shasta Framework and Shasta Cold Water Pool Management Plan will result in take of SR winter-run Chinook salmon, CV spring-run Chinook salmon, and CCV steelhead with the highest take levels occurring in Bin 3 years, which are expected to occur in fewer than 10 percent of years.

Ecological surrogates are used for SR winter-run Chinook salmon, CV spring-run Chinook salmon, and CCV steelhead in this Division because, as explained in the opinion, it is not practical to accurately quantify and monitor the actual amount or number of individuals that are reasonably expected to be taken. This is due to the variability in the population size at any given time of exposure to the stressors of water temperatures outside of the optimal temperature range of the species, alteration of water flow, annual variations in the timing of various parts of the species' life cycle, and variation in how individual fish use habitat within the action area.

11.3.1.1. Take Anticipated From Water Management/Temperature Effects

As described in the opinion, water temperatures in the Upper Sacramento River are expected to impact egg incubation and survival, juvenile growth and survival and affect the quantity and

quality of the limited habitat for adult spawning. NMFS cannot practically or accurately count the number of eggs, alevins, or fry that die due to water temperatures above their thermal tolerances. Temperature modeling can be used in combination with seasonal forecasts and assumed meteorological conditions to predict TDM; however, actual TDM will be a result of the observed temperatures and their interaction with the exposed individuals. This causal relationship between the water temperature and effects to fish is the basis for using daily average water temperature as a surrogate for estimating the extent of take for the listed salmonids. Although daily average water temperatures can be measured, the effect on each individual organism cannot be measured. Reclamation estimated this effect using a biological model that includes assumed individual responses. The anticipated incidental take from water temperature will vary based on the Bin-specific management objectives applied to the water year and Shasta cold water pool conditions.

As part of the ecological surrogate, NMFS anticipates the amount or extent of take of each of the listed salmonid species will be represented by the proportion of a life history stage that is exposed to a daily average water temperature greater than the specified temperature target at the downstream extent of their distribution in the mainstem Sacramento River.

11.3.1.1.1. Take of Sacramento River Winter-Run Chinook Salmon

Daily average water temperature and TDM are the metrics that are used to track incidental take of SR winter-run Chinook salmon from the operation of Shasta Reservoir. Water temperature and TDM depend on the operation of the Temperature Control Device on Shasta Dam and the available cold water pool. The available cold water pool depends on hydrology, meteorology, and releases. Some of the releases are required for flood control, senior water rights, water quality, and other purposes.

At the end of each temperature management season, Reclamation can use the observed temperature data to estimate the TDM of SR winter-run Chinook salmon under each Bin of the Shasta Framework and the Shasta Cold Water Pool Management Plan. Currently, this estimate is carried out using both the NMFS and the Anderson TDM models, as described in Reclamation's proposed action. This information will then be used to estimate the take of SR winter-run Chinook salmon due to the Shasta Cold Water Pool Management Plan.

The estimates of temperature-dependent egg mortality are inclusive for the entire period of time from the construction of the first redd until the final emergence. For the purpose of tracking the amount and extent of incidental take, TDM will be calculated at the end of the incubation period. Water temperature is tracked in real-time. Daily average water temperature is a reasonable ecological surrogate for real-time operations because it can be easily measured, and there are science-based relationships between water temperature and TDM. The amount and extent of incidental take is based on the Shasta Framework and Reclamation's commitment to operate to the Shasta Framework Objectives with an understanding that in Bin 2 and Bin 3 years, there may be exceedances depending on year-specific hydrologic conditions. Any exceedances would be anticipated during the development of the annual TMP.

NMFS anticipates the temperature-dependent egg mortality of SR winter-run Chinook salmon under the Shasta Framework's Shasta Cold Water Pool Management Plan as described below.

Although some Bin A and B conditions are the same, they are listed separately to avoid confusing during implementation and monitoring:

- Bin 1A – The amount and extent of anticipated take is framed around the Bin 1B objective of meeting a daily average water temperature of 53.5°F from May 15 through October 31 at or downstream of the CCR gage, which is expected to result in a TDM of ≤3 percent
- Bin 1B – The amount and extent of anticipated take is framed around the Bin 1B objective of meeting a daily average water temperature of 53.5°F from May 15 through October 31 at or downstream of the CCR gage, which is expected to result in a TDM of ≤3 percent (i.e., same as for Bin 1A)
- Bin 2A – The amount and extent of anticipated take is framed around the Bin 2A objective of meeting a daily average water temperature of 53.5°F from May 15 through October 31 at the CCR gage, which is expected to result in a TDM of ≤3 percent with up to a 10-percent deviation if it is incorporated through consensus into an annual TMP
- Bin 2B – The amount and extent of anticipated take is framed around the Bin 2B objective of meeting a daily average water temperature of 53.5°F from May 15 through October 31 at the CCR gage which is expected to result in a TDM of ≤3 percent at the CCR gage with up to a 10-percent deviation if it is incorporated through consensus into an annual TMP (i.e., same as for Bin 2A)
- Bin 3A – The amount and extent of take is framed around the Bin 3A objective of meeting a daily average water temperature of 53.5°F from May 15 through October 31, upstream from the CCR gage, which is expected to result in a TDM of ≤30 percent with a 1-year deviation of up to 10 percent if it is incorporated through consensus into an annual TMP
- Bin 3B - The amount and extent of take is framed around the Bin 3B objective of meeting a daily average water temperature of 53.5°F from May 15 through October 31, upstream from the CCR gage, which is expected to result in a TDM of ≤30 percent with a 1-year deviation of up to 10 percent if it is incorporated through consensus into an annual TMP

We anticipate the following conditions would indicate an exceedance of the amount and extent of incidental take:

- The amount and extent of anticipated incidental take will be exceeded if there are 2 consecutive Bin 3B years where TDM exceeds the objective of 30 percent, or,
- The amount and extent of anticipated incidental take will be exceeded if there are 2 consecutive Bin 3 years (either both Bin 3A or a combination of Bin 3A and Bin 3B years) that are accompanied by the JPE subteam making a determination in that second year, through a broodyear assessment, that SR winter-run Chinook salmon are in an "adverse condition" as defined in the proposed action

11.3.1.1.2. Take of Central Valley Spring-Run Chinook Salmon

NMFS anticipates the amount or extent of take of CV spring-run Chinook salmon under the Shasta Framework and the Shasta Cold Water Pool Management Plan will be represented by the proportion of redds that are exposed to a daily average water temperature over 53.5°F measured between Keswick Dam and Balls Ferry. NMFS also anticipates the amount and extent of take associated with daily average temperature up to 58.0°F at the CCR gage from March through

May for adult holding, prior to implementation of the annual water temperature management plan.

Incidental take of CV spring-run Chinook salmon is expected to be exceeded if the following conditions occur:

- The daily average water temperature exceeds 58.5°F at the CCR gage for three consecutive days between March 1 and May 31, or
- There are two consecutive Bin 3B years as described for SR winter-run Chinook salmon.

11.3.1.1.3. Take of California Central Valley Steelhead

Water temperature at Red Bluff Diversion Dam is used for CCV steelhead as part of the ecological surrogate because it approximates the downstream extent of their spawning distribution in the mainstem Sacramento River thus capturing the full extent of their spawning range. NMFS anticipates the amount or extent of take of CCV steelhead:

- Under the Shasta Framework and the Shasta Cold Water Pool Management Plan will be represented by the juveniles that are exposed to a daily average water temperature over 53.5°F, and
- Associated with water temperatures greater than 52°F at Red Bluff Diversion Dam from December through June for egg incubation.

Incidental take of CCV steelhead is expected to be exceeded if the following conditions occur:

- There are two consecutive Bin 3B years as described for SR winter-run Chinook salmon.

11.3.1.2. Take Anticipated From Flow Management

Changes in flow can be a stressor in the Upper Sacramento River but can also create benefits.

The proposed action is reasonably expected to result in the take of juvenile listed salmonids through stranding or redd dewatering throughout the Upper Sacramento River from Keswick Dam to Red Bluff Diversion Dam, resulting in reduced survival.

Take of SR winter-run Chinook salmon from changes in flow during the temperature management season is reasonably expected to result in egg mortality from the dewatering of 1 percent of redds.

Take of CV spring-run Chinook salmon resulting from flow changes from summer releases down to 3,250 cfs is reasonably expected to result in egg mortality from the dewatering of up to 3 percent of redds.

The anticipated level of take will be exceeded if a higher percent of redds are dewatered, or if flow decreases occur at a rate greater than the ramping rates described in the proposed action with the exception of flood control and emergency conditions.

11.3.2. Clear Creek

Reclamation's operation of Whiskeytown Dam above Clear Creek will seasonally create stressors of water temperature and flow changes that are reasonably expected to result in take of CV spring-run Chinook salmon and CCV steelhead, resulting in reduced survival.

Temperature surrogates are used for Clear Creek because, as described in this opinion, it is not practical to accurately quantify and monitor the amount or number of individuals that are expected to be taken. This is due to the variability in the population size at any given time of exposure to the stressors of water temperatures outside of the optimal temperature range of the species, alteration of water flow, the annual variations in the timing of various parts of the species' life cycles, and variation in how individual fish use habitat within Clear Creek.

11.3.2.1. Take Anticipated From Water Temperature Effects of Water Management

Suboptimal water temperatures in Clear Creek are expected to result in reduced survival and reproductive stress for CV spring-run Chinook salmon. Because of the causal relationship between temperature and survival within and between life stages, temperature will be used as a surrogate for the amount or extent of take for salmonids. The ecological surrogate to define the amount or extent of take in Clear Creek is both the magnitude and frequency of suboptimal water temperature in the reach from Whiskeytown Dam to the Igo temperature gage. The extent of take is measured by the appropriate life stage habitat between Whiskeytown Dam and the Igo gage exposed to temperatures that exceed the proposed temperature management target.

The ecological surrogate for the amount or extent of take of CV spring-run Chinook salmon egg-to-fry life stage is the daily average temperature at the Igo gage when eggs are in the gravel incubating. This is expected to occur between September and November. Fry emergence typically occurs from late-October to January, when water temperatures are cooler.

Because Whiskeytown Reservoir is almost completely reliant on trans-basin diversions and infrastructure from the Trinity River watershed to replenish and sustain cold water pool resources to extend thermal protections to Clear Creek, the take limit is defined by available storage in Trinity Reservoir. Overall storage is used as a surrogate for sufficient cold water pool resources in Trinity Reservoir. Years in which the Trinity Reservoir volume available is in excess of 2.0 MAF at the end of April and facilities are capable to function at capacity, the anticipated level of take will be exceeded if the average daily water temperature at the Igo gage exceeds 56°F for longer than 7 consecutive days or exceeds 57°F for any single day from September 16 to November 15. In years where Trinity Reservoir volume is less than 2.0 MAF but greater than or equal to 1.5 MAF at the end of April, the anticipated level of take will be exceeded if the average daily water temperature exceeds 57°F for longer than 7 consecutive days. Poor Trinity Reservoir storage years, defined as years when end of April volumes are less than 1.5 MAF, or times when infrastructure is impaired will require input from the CCTT and/or SRTTG to achieve an acceptable balance between temperature and flow results in the Trinity and Sacramento rivers. For these years, the anticipated level of take will be highly variable and interrelated with the Sacramento River expected take, but will be exceeded if the average daily water temperature exceeds 59°F for longer than 7 consecutive days.

The ecological surrogate for the amount or extent of take of the CV spring-run Chinook salmon adult life stage is the daily average temperature at the Igo gage from June 1 to September 15.

The anticipated level of take will be exceeded if the daily average temperature at the Igo gage exceeds 61°F from June 1 through August 15 for longer than 7 consecutive days or exceeds 62°F for any single day, and 60°F from August 16 through September 15 for longer than 7 consecutive days or exceeds 61°F for any single day.

11.3.2.2. Take Anticipated From Flow Management

The ecological surrogate for the amount or extent of take during spring attraction and channel maintenance pulse flows of the CV spring-run Chinook salmon and CCV steelhead egg-to-fry life stage is the rearing or incubating habitat exposed to flow reductions during controlled flow decreases from Whiskeytown Reservoir, consistent with established ramp-down rates, leading to fish stranding or redd dewatering, resulting in reduced survival.

The ecological surrogate for the amount or extent of take from instream flows for the CV spring-run Chinook salmon and CCV steelhead egg-to-fry life stage is flow lower than 150 cfs for all water year types except critical water year types, which could go below 100 cfs depending on the available water supply, resulting in reduced survival.

The anticipated level of take will be exceeded in non-critical years if flows in Clear Creek, as measured at Igo, are lower than 150 cfs between October 1 and May 31 and lower than 100 cfs from June 1 to September 30.

11.3.3. American River Division

Reclamation's proposed action in the American River Division will create stressors of water temperature and flow that are reasonably expected to result in take of CCV steelhead.

Surrogates are used for this Division because, as described in the opinion, it is not practical to accurately quantify and monitor the amount of individuals that are expected to be taken due to the co-occurrence of non-listed steelhead from the Nimbus Fish Hatchery Program in the American River. Surrogates may also be used due to the variability in the proportion of the population at any given time of exposure to the stressors of water temperatures outside of the optimal temperature range of the species, lack of quantification for optimal water flows for species in the American River, the annual variations in the timing of various parts of the species' life cycles, and variation in how individual fish use habitat within the American River. Because of the causal relationship of flow magnitude, timing, duration, frequency, and rate of change to survival within and between life stages, flow can be used as a surrogate for the amount or extent of take for salmonids.

11.3.3.1. Take Anticipated From Water Temperature and Dissolved Oxygen Effects

Suboptimal water temperatures in the American River are expected to result in reduced survival during the egg-to-fry life stage and reduced growth for the juvenile rearing and smolt emigration life stages for CCV steelhead as described in the opinion.

The ecological surrogate to define the amount or extent of take in the American River is both the magnitude and frequency of suboptimal water temperature in the reach from Nimbus Dam to Watt Avenue (as measured at Watt Avenue).

The CCV steelhead egg-to-fry life stage occurs from December through May, and temperatures above 54°F create suboptimal conditions for this life stage. A small proportion of CCV steelhead eggs or alevins will still be in redds during May when they will potentially be exposed to water temperatures that will reasonably be expected to result in mortality. The extent of take is the redds that are exposed to daily average water temperatures above 54°F at Watt Avenue from December 1 through May 31.

The anticipated level of take will be exceeded if the monthly average temperature in March is greater than 54°F at Watt Avenue in consecutive years.

Reduced survival of CCV steelhead juveniles are anticipated at daily average water temperatures at or above 68°F. The ecological surrogate to define the amount or extent of take of the CCV steelhead juvenile life stage is the daily average temperature greater than 68°F at Watt Avenue from May 15 to October 31, as described below.

The anticipated level of take will be exceeded if daily average water temperatures at Watt Avenue exceed 68°F from May 15 to October 31 for more than 7 consecutive days unless it is a critical year based on the Sacramento Valley Index or a year following 1 or more critical years.[23] In critical years, and years immediately after a critical year, the anticipated level of take is exceeded if the daily average water temperature exceeds 68°F at Hazel Avenue for more than 7 consecutive days.

11.3.3.2. Take Anticipated From Flow Management

Flow fluctuations in the Lower American River are expected to result in CCV steelhead redd dewatering and isolation. Redd dewatering can affect salmonid eggs and alevins by impairing development and causing direct mortality due to desiccation, insufficient oxygen levels, waste metabolite toxicity, and thermal stress. Flow fluctuations are also reasonably expected to result in the stranding of juvenile CCV steelhead in isolated pools where desiccation, insufficient oxygen levels, thermal stress, or predation would lead to mortality.

The flow regime of a water body is defined by its flow magnitude, timing, duration, frequency, and rate of change. Literature reviews have shown that usable habitat and fish abundance, diversity, and demographic rates can decline in response to both elevated and reduced flow magnitude. Because of the causal relationship of flow magnitude, timing, duration, frequency, and rate of change to survival within and between life stages, flow will be used as a surrogate for the amount or extent of take for listed salmonids.

The ecological surrogate to define the amount or extent of take for CCV steelhead egg-to-fry is the extent of egg habitat that is dewatered and exposed to the stressors from lower flows from January through May, resulting in reduced survival. Take will be exceeded if flows decrease below the Minimum Release Requirement from January through May (see Table 65 and Table 66 in this opinion).

The ecological surrogate to define the amount or extent of take of CCV steelhead juvenile life stages is the ramping rate that results in isolation, resulting in reduced survival. Take will be exceeded if flow decreases occur at a rate greater than the ramping rates described in the proposed action (see Table 67; American River Division of the BA), with the exception of flood control or emergency conditions.

The ecological surrogate to define the amount or extent of take of the CCV steelhead egg-to-fry life stage from redd scouring is flow magnitude and rate created by releases from Nimbus Dam during egg incubation (i.e., January through May), resulting in reduced survival.

[23] In a critical year, or year following a critical year, Reclamation will meet with NMFS, USFWS, CDFW, and the SWRCB to discuss and determine the best use of the limited cold water pool for that year.

Take will be exceeded if flows are higher than 50,000 cfs in the American River from January to May, with the exception of flood control or emergency conditions.

11.3.4. Stanislaus River (East Side Division)

The proposed action is reasonably expected to create the stressors of water temperature and flow conditions resulting in take of CCV steelhead and CV spring-run Chinook salmon in the Stanislaus River, which is part of the East Side Division.

Surrogates are used for this Division because it is not practical to accurately quantify and monitor the number of individuals that are reasonably expected to be affected by the proposed action due to the variability in the population size at any given time of exposure to the stressors of water temperatures outside of the optimal temperature range of the species, alteration of flow conditions and the annual variations in the timing of various parts of the species' life cycles, and variation in how individual fish use habitat within the Stanislaus River.

11.3.4.1. Take Anticipated From Water Temperature Effects

Suboptimal water temperatures in the Stanislaus River are reasonably expected to result in reduced survival during the egg-to-fry life stage and reduced growth for the juvenile and smolt life stages for CCV steelhead and CV spring-run Chinook salmon.

The ecological surrogate used to define the extent of take in the Stanislaus River is described by both the magnitude and frequency of suboptimal water temperature in the reach from Goodwin Dam to Orange Blossom Bridge during times when CCV steelhead and CV spring-run Chinook salmon are present. Because of the causal relationship of the timing, duration, and frequency of temperature exceedance to survival within and between life stages, temperature will be used as a surrogate for the amount or extent of take for listed salmonids.

The CCV steelhead egg-to-fry life stage occurs from December through May, and temperatures above 54°F create suboptimal conditions for this life stage. A small proportion of CCV steelhead eggs will still be in redds during May and exposed to water temperatures that will be expected to result in egg mortality. The extent of take is a small proportion of redds exposed to daily average water temperatures above 54°F down to Orange Blossom Bridge from December 1 through May 31. Take of CCV steelhead during the egg-to-fry life stage during these months is expected to be minimal because few eggs would still be in redds.

CV spring-run Chinook salmon egg-to-fry life stage occurs from August through February, where daily average water temperatures above the 54°F criterion create suboptimal conditions for the early life stages. The extent of take is redds exposed to daily average water temperatures above 54°F at Orange Blossom Bridge from August 1 through February 28.

Reduced survival is anticipated at daily average water temperatures at or above 68°F. The ecological surrogate to define the amount or extent of take of CCV steelhead juveniles that remain in the upper river is the daily average temperature at Orange Blossom Bridge from March 1 to October 31. Likewise, the ecological surrogate used to define the amount or extent of take of CV spring-run Chinook salmon juveniles in the upper river is the daily average temperature at Orange Blossom Bridge from March 1 to October 31.

The anticipated level of take will be exceeded if daily average water temperatures at Orange Blossom Bridge exceed 68°F from March 1 to October 31 for more than 7 consecutive days

unless Reclamation and NMFS agree that it is an acceptable exceedance given the hydrologic and meteorological conditions for that year.

11.3.4.2. Take Anticipated From Flow Management

Reclamation proposes to operate New Melones Reservoir (as measured at Goodwin Dam) in accordance with an SRP that varies by hydrologic condition/water year type. The maximum scheduled release rate under the SRP is 3,000 cfs during a spring pulse flow, thus higher flow events will likely only occur during flood control or other reservoir storage management actions. The SRP also includes low flows (150 cfs to 300 cfs) in the summer months. Flows below 3,000 cfs limit the floodplain rearing areas for juvenile CCV steelhead and CV spring-run Chinook salmon, and low summer flows can delay smolt out-migration. Because of the causal relationship of flow magnitude, timing, duration, frequency, and rate of change to survival within and between life stages, flow is used as a surrogate for the amount or extent of take for listed salmonids.

The ecological surrogate to define the amount or extent of take of CCV steelhead and CV spring-run Chinook salmon in the Stanislaus River is flow. Flows affect all life stages of these fish that occur in the Stanislaus River and represent the causal link between the proposed action and survival. Take will be exceeded if flow releases to the Stanislaus River measured at Goodwin Dam decrease to levels lower than the SRP or those scheduled by the SWT.

11.3.5. Bay-Delta Division

The Bay-Delta Division includes multiple proposed action components that are reasonably expected to result in take of SR winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon. Take is anticipated from agricultural barriers, operation of the Delta Cross Channel gates, operation of pumping facilities, operation of water diversions into sloughs and aqueducts, sediment and weed control operations, and predator control studies.

11.3.5.1. Agricultural Barriers

Incidental take of a medium proportion of CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon is expected during the seasonal operation of the three temporary agricultural barriers. NMFS cannot precisely quantify and track the amount of individuals that are expected to be taken because there are no site-specific monitoring programs available at the proposed agricultural barrier locations that would allow quantification.

The surrogate to define the amount or extent of take is the operation of the temporary barriers based on the duration of operation (i.e., time between installation date and removal date). The installation, removal, and operation of the barriers have a causal link to take because it defines the effect to the habitat used by all listed species, resulting in changes in fish behavior and survival. The alteration in the functioning of the channel habitat causes changes in fish behavior, such as migratory delays, and increases the vulnerability of fish to predation through increased exposure time to predators residing in waters adjacent to the temporary agricultural barriers.

The anticipated level of take will be exceeded if the operation of the barriers occurs earlier than May 1, or if the barriers are not removed by November 30 of each year, or mean daily water temperatures are below 71.6°F (22°C) at Mossdale, and fish passage is precluded by barriers.

11.3.5.2. Delta Cross Channel Gates

Incidental take of ESA-listed fish is expected in the forms of injury, harm, or death when the Delta Cross Channel gates are open and listed fish are present. Listed fish would be exposed to altered flows and diverted into the Central and South Delta and reasonably expected to result in an increase to routing time, exposure to predation, higher water temperatures, and lower quality habitat.

Migration of juvenile salmonids from the Sacramento River is monitored via the Knights Landing Index and the Sacramento Catch Index. Based on catch indices at these locations, Reclamation may close the Delta Cross Channel gates to protect migrating fish as they arrive at the Delta Cross Channel gates. These numeric triggers are applied to protect all listed species. Indices are to follow the normal rounding rule to the tenth.[24] While there are some modeling tools that can estimate routing at the Delta Cross Channel, NMFS cannot precisely quantify and track the amount of individuals that are reasonably expected to be taken per species because there are no site-specific monitoring programs available at the Delta Cross Channel that would allow for quantification. The ecological surrogate is the frequency and duration of opening the Delta Cross Channel gates in the October through January time period. Because of the causal relationship of gate opening to exposure of increased stressors across for the rearing and migration life stages, the frequency and duration of opening will be used as a surrogate for the amount or extent of take for listed salmonids. The anticipated level of take for SR winter-run Chinook salmon, CV spring-run Chinook salmon and CCV steelhead low and will be exceeded if the number or duration of openings exceed those described in the proposed action.

11.3.5.3. Central Valley Project and State Water Project Pumping Facilities

The operation of CVP and SWP pumping facilities is reasonably expected to result in the take of listed SR winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead and green sturgeon in the forms of injury, harm, or mortality. Routine periodic biological sampling is done during salvage operations at pumping facilities to monitor for the presence of listed fish, providing a direct measure of the take of species at the pumping facilities. Diversions also result in altered routes and entrainment into the Central Delta that are expected to result in increased migration time, exposure to predation, and impingement of fish, resulting in reduced survival. Therefore, the individual listed fish in the periodic samples not only represent those fish taken at the facilities, but also provide a surrogate for the take of other individuals of each listed species that are entrained or whose migration route has been altered by a CVP or SWP diversion. We anticipate the following amount and extent of incidental take related to the export facilities, as shown in Table 184:

[24] Normal rounding rule: digits 1, 2, 3, and 4 round down, and digits 5, 6, 7, 8, and 9 round up. For example, 10.11 rounds to 10.1; 10.15 rounds to 10.2.

Table 184. Annual amount and extent of anticipated incidental take of listed species at the Bay-Delta pumping facilities. Note that the amount and extent of incidental take differ from the operational loss thresholds in the proposed action because they are based on an analysis of anticipated take rather than loss levels that trigger operational actions.

Species	Measurement	Maximum Anticipated Annual Amount and Extent of Take	Rationale
Sacramento River (SR) winter-run Chinook salmon	Loss of natural genetic SR winter-run Chinook salmon.	0.56% of the natural winter-run juvenile production estimate (JPE) in any single year or 0.36% on a 3-year rolling average of the JPE.	Data period is Water Years (WY) 2010–2022, since quality-controlled genetic data from WY 2023–2024 is not available.[1]
SR winter-run Chinook salmon	Loss of hatchery SR winter-run Chinook salmon - Sacramento River.	1.0% of the estimated hatchery JPE (fish surviving to the Delta) from Livingston Stone National Fish Hatchery released into the Upper Sacramento River in a single year or 0.8% of the JPE on a 3-year rolling average.	Upper limit of anticipated amount and extent of take based on the JPE.
SR winter-run Chinook salmon	Loss of hatchery SR winter-run Chinook salmon - Battle Creek	1.0% of the estimated hatchery JPE (fish surviving to the Delta) from Livingston Stone National Fish Hatchery released into Battle Creek in a single year or 0.8% of the JPE on a 3-year rolling average.	Upper limit of anticipated amount and extent of take based on the JPE.
Central Valley (CV) spring-run Chinook salmon - yearlings	Loss of CV spring-run Chinook salmon surrogates as described in the proposed action	0.5% of the estimated number of each surrogate release group	Double the operational loss threshold of 0.25% for each surrogate release group.

Species	Measurement	Maximum Anticipated Annual Amount and Extent of Take	Rationale
California Central Valley (CCV) steelhead (naturally produced)	Loss of unclipped CCV steelhead	5,294 juveniles in any single year or 2,319 juveniles as a 3-year rolling average for a period of up to 5 years after the ROD, after which we expect an alternative amount and extent of take is expected that scales incidental take to population size based on a JPE or other similar mechanism. If there is a delay in the JPE schedule, Reclamation may request an extension past the 5-year mark.	Data period is WY 2010–2024.[1]
Southern Distinct Population Segment (sDPS) of North American green sturgeon	Salvage of sDPS green sturgeon	14 green sturgeon in a single year, or 5 on a 3-year rolling average	Data period is WY 2010–2024.[2]

[1] The 1-year incidental take limit is based on the maximum single-year loss observed within the specified historical dataset. The 3-year incidental take limit is based on the maximum three-consecutive-year average loss observed within the specified historical dataset. For genetic Sacramento River winter-run Chinook salmon, maximum loss is based on a percentage of the juvenile production estimate, where in NMFS' 2019 Opinion, we used length at date.

[2] The 1-year incidental take limit is based on the maximum single-year salvage observed within the specified historical dataset. The 3-year incidental take limit is based on the maximum three-consecutive-year average salvage observed within the specified historical dataset.

11.3.5.4. Spring Delta Outflow

With the intent of realizing the potential benefits of the Spring Delta Outflow actions deployed in the Bay-Delta Division, Reclamation and DWR will forgo a volume of Delta exports to supplement Delta outflow in dry, below normal, and above normal water year types for the pre-VA adoption period. This action is expected to minimize take related to OMR management during the pre-adoption period and we do not anticipate an increase in the amount and extent of take over what is already anticipated and analyzed from OMR Management.

11.3.5.5. Contra Costa Water District - Rock Slough Diversion

The Contra Costa Water District diverts water from the Delta for irrigation and municipal and industrial uses under its CVP contract. ESA-listed fish are reasonably expected to be taken in the forms of injury, harm, or death when the Rock Slough Diversion is operating and listed fish are present. Listed fish would be exposed to altered flows and diverted resulting in increased routing

time, exposure to predation, higher water temperatures, and lower quality habitat that would decrease the survival of juvenile fish.

An ecological surrogate is used because NMFS cannot precisely quantify and track the amount of individuals that are reasonably expected to be taken per species.

The ecological surrogate to define the amount or extent of take associated with operation of the Rock Slough Diversion is habitat alteration caused by the diversion of water through the intake's fish screens that allows Delta water to flow towards the facility. The ecological surrogate for take of listed SR winter-run Chinook salmon, CV spring-run Chinook salmon, and CCV steelhead will be the maximum permitted diversion rate of 350 cfs, which is expected to affect a small proportion of the populations. If diversion of water through the Rock Slough Diversion intake exceeds this rate, then the anticipated level of take will have been exceeded.

11.3.5.6. Suisun Marsh Salinity Control Gates

Take of ESA-listed fish will reasonably be expected to occur in the forms of injury, harm, or death when the SMSCG are operating from June through September for the Delta smelt summer-fall habitat action and October through May for salinity control when listed fish are present. The SMSCG is expected to alter fish behavior, including migratory delays for both adult upstream migrants and smolt out-migrants. Listed fish would also be exposed to increased predation through increased exposure time in the channel of Montezuma Slough adjacent to the radial gates. This action may occur year-round, with most gate closures occurring from June to October, when listed fish are less likely to be present. Gate closures are expected to have the greatest impact on adult CV spring-run Chinook salmon and adult CCV steelhead migration, but also by delaying juvenile salmonids and sDPS green sturgeon migration. An ecological surrogate is used because NMFS cannot precisely quantify and track the amount of individuals that are reasonably expected to be taken.

The ecological surrogate to define the amount or extent of take of listed salmonids associated with the operation of the SMSCG will be the habitat alteration caused by the closure of the radial gates during flood tides within the periods of operations. The installation, removal, and operation of the facility has a causal link to take because it defines the effect to the habitat used by all listed species as well as the exposure to changes in fish behavior and exposure to predation, resulting in decreased survival. The ecological surrogate for take of SR winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon is the operation of the SMSCG pursuant to Section 3.7.6.2 of the proposed action, which is expected to affect a small proportion of populations. If the SMSCG are operated in a manner that results in additional adverse effects not considered as part of the annual Summer-Fall Habitat Action Plan, the anticipated level of take of listed salmonids and sDPS green sturgeon will have been exceeded.

11.3.5.7. Barker Slough Pumping Plant and the North Bay Aqueduct Intake

Entrainment through salvage and impingement is expected at the Barker Slough and North Bay Aqueduct intakes. An ecological surrogate is used because NMFS cannot precisely quantify and track the amount of individuals that are expected to be taken. The ecological surrogate for take of listed SR winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon will be the maximum daily diversion rate of 175 cfs and a cumulative

Barker Slough diversion for the January 1 to March 31 period, at design capacity which is limited to approximately 26 TAF.

If the Barker Slough Pumping Plant and the North Bay Aqueduct intakes are operated in a manner that results in additional adverse effects that were not analyzed as part of the proposed action, then the anticipated level of take of listed salmonids and sDPS green sturgeon will have been exceeded.

11.3.5.8. Barker Slough Pumping Plant Sediment and Weed Control Operations

Take of ESA-listed fish is reasonably expected in the forms of injury, harm, or death during sediment and weed control operations in Barker Slough. Take is minimized by the standard operating procedures provided in the BA (U.S. Bureau of Reclamation 2023-2024) for fish screen cleaning and the removal of sediment and aquatic weeds to maintain fish screen functionality at Barker Slough Pumping Plant.

The anticipated level of take will be exceeded if more than five (5) unclipped listed salmonids (cumulative) are entrained per year through any combination of SR winter-run Chinook salmon, CV spring-run Chinook salmon, and CCV steelhead. The anticipated level of take for sDPS green sturgeon will be exceeded if more than two (2) fish are entrained per year (Table 185).

Table 185. Incidental take for sediment removal and aquatic weed control at Barker Slough.

Action	Cumulative Take of Juvenile Salmonids (Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and California Central Valley steelhead) Individuals/year	Cumulative Take of Juvenile sDPS Green Sturgeon/ year
Sediment Removal	5	2
Weed Removal	5	2

11.3.5.9. Clifton Court Forebay Weed Management

DWR will apply herbicides and algaecides or will use mechanical harvesters on an as-needed basis to control aquatic weeds and algal blooms in the CCF. The Clifton Court Forebay Aquatic Weed Management Standard Operating Procedures document provided in the BA materials (U.S. Bureau of Reclamation 2023-2024) provides details for CCF Weed Management, including best management practices to minimize adverse effects to listed species. If CCF weed management is implemented in a manner that results in additional adverse effects that were not analyzed as part of the proposed action, then the anticipated level of take of listed salmonids and sDPS green sturgeon will have been exceeded.

11.3.6. Southern Resident Killer Whales

NMFS anticipates the proposed action will result in incidental take in the form of harm to SRKW individuals by reducing prey availability and impairing feeding behavior when SRKWs forage for longer periods without success, migrate to alternate locations to seek prey, and experience nutritional stress and related health effects. Currently, we cannot observe or quantify impacts to foraging behavior of individual killer whales in the population from the general level of prey reduction that has been described in the proposed action because we do not have the data or metrics needed to monitor and establish relationships between the effects of the proposed action and individual SRKW health. As a result, we will rely on surrogates in the form of effects to listed and non-listed Chinook salmon populations coextensive to the effects analysis described in the Southern Resident Killer Whale Effects Analysis section and the Integration and Synthesis for Southern Resident Killer Whales section. Therefore, the extent of take for SRKWs will be exceeded if: (1) the take for CV spring-run Chinook salmon is exceeded; (2) the take for winter-run Chinook salmon is exceeded; or (3) operations vary outside of those described in the proposed action.

11.4. Effect of the Take

In the opinion, NMFS determined that the amount or extent of anticipated incidental take, coupled with other effects of the proposed action, is not likely to result in jeopardy to the species or destruction or adverse modification of critical habitat.

11.5. Reasonable and Prudent Measures

"Reasonable and prudent measures" refer to those actions the Director considers necessary or appropriate to minimize the impact of the incidental take on the species (50 CFR 402.02). NMFS believes the following reasonable and prudent measures are necessary and appropriate to minimize take of SR winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, sDPS green sturgeon, and SRKWs:

1. Reclamation shall minimize the impact of the amount or extent of incidental take of listed species during operations of the Shasta Division.

2. Reclamation shall minimize the impact of the amount or extent of incidental take of listed species during operations in the Clear Creek Division during operations of Whiskeytown Dam.

3. Reclamation shall minimize the impact of the amount or extent of incidental take of listed species during operations of the American Division.

4. Reclamation shall minimize the impact of the amount or extent of incidental take of listed species during operations of the East Side Division.

5. Reclamation and DWR shall minimize the impact of the amount or extent of incidental take of listed species during operations of the Bay-Delta Division.

6. Reclamation and DWR shall minimize the impact of the amount or extent of incidental take of SRKWs during operations.

7. Reclamation and DWR shall monitor and report the amount and extent of take to NMFS by preparing and providing NMFS with plans and reports describing how impacts of the incidental take on listed species in the action area would be monitored and documented.

8. Reclamation and DWR shall develop conservation measures for CCV steelhead including actions that accelerate steelhead science, develop population-based approaches to minimize entrainment, and minimize entrainment of CCV steelhead into the South and Central Delta and export facilities.

9. Reclamation and DWR shall, to the extent feasible and practicable, coordinate implementation of spring pulse flows through SHOT and WOMT to help improve spring out-migration conditions and CV spring-run Chinook salmon survival.

11.6. Terms and Conditions

In order to be exempt from the prohibitions of section 9 of the ESA, the federal action agency must comply (or must ensure that any applicant complies) with the following terms and conditions. Reclamation and DWR have a continuing duty to monitor the impacts of incidental take and must report the progress of the action and its impact on the species as specified in this incidental take statement (50 CFR 402.14). If the entity to whom a term and condition is directed does not comply with the following terms and conditions, protective coverage for the proposed action would likely lapse. Reclamation and DWR must ensure compliance by their contractor(s) with the following terms and conditions, which implement the reasonable and prudent measures described above.

1. **The following terms and conditions implement reasonable and prudent measure 1 for the Shasta Division:**

    a. In coordination with NMFS and the SRG, Reclamation shall consider technical assistance from NMFS regarding the development of annual TMPs, regardless of Shasta storage bin or temperature management stratum. Reclamation shall submit the final TMP to NMFS by May 20 of each year, as reporting under the opinion unless the SHOT agrees, through consensus, on a later date.

    b. By February of each year, Reclamation shall provide a hindcast report of TDM for SR winter-run Chinook salmon based on realized temperature management. The report shall include performance trends to date and observed range of TDM within Bins.

    c. If the biological objectives of a Bin are exceeded, Reclamation, in coordination with NMFS, shall initiate an independent review of operations to determine if there were discretionary actions that could have been taken by Reclamation to meet the biological objectives. The review shall be initiated in November with a draft report available in March so that any recommendations can be considered for incorporation into the next year's TMP.

    d. If there are two consecutive Bin 3 years in a row, the SHOT will convene to conduct a full review of conditions and operations and will make a recommendation to the Directors Group on whether reinitiation is warranted or if

other operational actions could be taken to prevent a third consecutive Bin 3 year. The SHOT may also work with the WRAP policy team to update the WRAP actions and make recommendations to the Directors Group for implementation and addressing potential barriers to implementation. The SHOT may also recommend an independent review of operations and WRAP actions and request recommendations for adjusting operations and WRAP actions that may be necessary to protect SR winter-run Chinook salmon survival and viability.

e. If the JPE subgroup makes two consecutive determinations that SR winter-run Chinook salmon are in an "adverse condition," and the SHOT reaches consensus on that determination, Reclamation, in coordination with other SHOT agencies, will review and update the WRAP actions and make recommendations to the Directors Group for immediate implementation and to addressing potential barriers to implementation.

2. The following terms and conditions implement reasonable and prudent measure 2 for the Clear Creek:

a. To minimize incidental take under the 61°F and 60°F daily average water temperature criteria for over-summering CCV steelhead and adult CV spring-run Chinook salmon holding and 56°F daily average water temperature criteria for CV spring-run Chinook salmon egg incubation, Reclamation shall:

i. Provide annual update reports on continued maintenance of temperature control curtains (Oak Bottom and Spring Creek) in Whiskeytown Reservoir.

ii. Through coordination with the CCTT, consider real-time species information when making decisions regarding operational adjustments. This does not mean that the information will require operations to differ from what is contained in the final proposed action.

iii. Notify NMFS within 24 hours of mean daily average water temperature exceedances and work with the CCTT to discuss options to adjust operations to minimize the duration of the exceedance.

iv. Proactively determine if mean daily water temperature may be exceeded and release water from Whiskeytown Dam to avoid exceeding water temperature requirements.
    a. If a water temperature requirement is close to being exceeded, Reclamation shall coordinate with NMFS and the CCTT on what operational adjustments could avoid an exceedance to best protect listed fish that are present.

v. In critical years, coordinate with NMFS through the CCTT and/or the SRTTG on the timing, frequency, duration, and magnitude of flows below 150 cfs. The purpose is to ensure enhanced coordination in critical years when fish tend to face higher risks.

b. Reclamation shall continue implementation of a weir annually to separate CV spring-run Chinook salmon and fall-run Chinook salmon during spawning to minimize the effects of redd superimposition and hybridization.

c. To minimize the adverse effects of flow fluctuations associated with CVP-controlled water operations on all life stages of listed anadromous fish species in Clear Creek, Reclamation shall coordinate flow release schedules with NMFS, USFWS, and CDFW via the CCTT or a comparable inter-agency fish monitoring group.

3. The following terms and conditions implement reasonable and prudent measure 3 for the American Division:

a. Reclamation shall install a dissolved oxygen gage with data available real-time, e.g., on CDEC, in order to monitor this water quality parameter just below Nimbus Dam and at an additional location between Nimbus Dam and Watt Avenue Bridge.

b. Reclamation shall ensure stranding monitoring and rescue is conducted when implementing alternative/adaptive ramping rates developed by the ARG.

4. The following terms and conditions implement reasonable and prudent measure 4 for the East Side Division:

a. Reclamation shall complete the Initial Alternatives Report of the New Melones SRP by December 31, 2025. Completion of the Initial Alternatives Report will include initial findings for the identified management questions and modeling under development.

b. Reclamation shall make decisions affecting the application of the Minimum Instream Flow seasonal flow volumes through coordination in the SWT and according to the following priorities:

i. Scheduling of Winter Instability Flows and Spring Pulse Flows will consider and prioritize shaping flow volumes to simulate more natural variability in the hydrograph to maximize the effectiveness of migratory cues and access to rearing habitats. If the consensus of the SWT determines that rain events would meet the intent of the Winter Instability Flows without additional reservoir releases, Reclamation shall prepare an assessment of river conditions supporting the determination. That assessment shall be provided to the members of the SWT as well as the WOMT.

ii. Scheduling of Fall Pulse Flows will consider and prioritize shaping flow volumes to simulate more natural variability in the hydrograph to maximize the effectiveness of adult salmonid attraction cues. In consideration of other system objectives, the SWT may provide advice on how best to meet multiple beneficial objectives, where Reclamation shall

prepare a summary of considerations affecting the shaping of the Fall Pulse Flow volume. That summary shall be provided to the members of the SWT as well as the WOMT.

c. When considering alternative ramping rates developed by the SWT, at Goodwin Dam, Reclamation, through the SWT, shall coordinate the monitoring of spawning habitat below the dam so as to assess the potential, and realized, effect of the change in flow.

d. Reclamation shall provide to NMFS an annual water temperature dataset and provide summary statistics.

e. Reclamation shall provide to NMFS an annual report of incidental take associated with monthly temperatures and provide an assessment of temperature conditions over the year, including monthly average data at Orange Blossom Bridge.

5. The following terms and conditions implement reasonable and prudent measure 5 for the Bay-Delta Division:

a. Reclamation and DWR shall monitor the salvage and loss of SR winter-run Chinook salmon, CV spring-run Chinook salmon, CV fall-run Chinook salmon, CV late fall-run Chinook salmon, sDPS green sturgeon, and CCV steelhead associated with the operation of the CVP's Jones and SWP's Harvey Banks pumping facilities.

i. Reclamation and DWR shall monitor and calculate salvage and loss for SR winter-run Chinook salmon, CV spring-run Chinook salmon, CV fall-run Chinook salmon, CV late fall-run Chinook salmon, CCV steelhead, and salvage of sDPS green sturgeon at the Tracy Fish Collection Facility and Skinner Delta Fish Protective Facility.

a. Reclamation and DWR shall prepare and submit to NMFS daily reports from October 1 through June 30 of each water year (or provide data online) regarding the observations of both salmonids and sDPS green sturgeon in the fish salvage facilities. Daily salvage sheets and all necessary operational information needed to calculate salvage and loss shall be provided to NMFS (to a list of recipients updated each water year) or made available online. If, during the period from July 1 to September 30, salmonids and/or sDPS green sturgeon are observed in salvage, Reclamation and/or DWR shall notify NMFS through electronic mail and include the daily salvage sheets and operational information or direct NMFS to where this information is available online.

b. During the October through June period of each water year, DWR and Reclamation shall prepare and submit to NMFS, the Delta operations for salmonids and sturgeon, and other relevant technical teams' weekly reports summarizing salvage and loss over the

previous week and for the water year to date (or provide data online).

c. No later than December 31 of each year, Reclamation and DWR shall submit to NMFS an annual report summarizing salvage and loss over the previous water year (October 1 to September 30).

ii. Reclamation and DWR shall undertake tissue sampling programs from natural-origin salmonids and CWT samples from adipose fin-clipped juvenile SR winter-run Chinook salmon, CV spring-run Chinook salmon, and CV late-fall run Chinook salmon at the Tracy Fish Collection Facility and Skinner Delta Fish Protective Facility for genetic analysis or tag removal/reading pursuant to appropriate sampling protocols and statistical power analyses.

a. Reclamation and DWR shall submit incidental take reports from Tracy Fish Collection Facility and Skinner Delta Fish Protective Facility by December 31 of each year, to include the genetic results of the tissue samples.

b. To advance the scientific understanding of CCV steelhead and to use that information to reduce loss of natural origin CCV steelhead from both the San Joaquin and Sacramento river basins, Reclamation and DWR shall, in coordination with NMFS and the SWFSC, subsample steelhead from Tracy Fish Collection Facility and Skinner Delta Fish Protective Facility for determining basin of origin and managing future surrogate methods for managing entrainment and loss. The coordination with NMFS and the SWFSC will focus on developing specific subsampling protocols and coordinating protocols with other steelhead science efforts connected with CVP and SWP operations.

b. On an annual basis, Reclamation and DWR shall discuss and confirm through WOMT the operational protocol for determining when the CVP and SWP export facilities would forgo water diversion volume pursuant to the pre-adoption period of the Delta VAs. This should include the date by which the water year type will be determined, on which exceedance forecast the water year type determination will be based, and a proposed schedule to achieve the total volume of forgone exports.

i. This accounting protocol shall be discussed through WOMT coordination, and, once developed, Reclamation and DWR shall report out through WOMT the accounting of the volume of water contributing to the forgone export.

c. Reclamation shall implement the following term and condition related to Delta Cross Channel gate operations:

i. In order to streamline the decision process for implementing Delta Cross Channel gate closures based on the Knights Landing Catch Index and the

Sacramento Catch indices (both of which use juvenile captures), Reclamation shall follow normal rounding rule to the tenth. The catch indices shall be 3.0 fish per day and 5.0 fish per day.

d. DWR shall incorporate the following terms and conditions related to North Bay Aqueduct/Barker Slough Pumping Plant operations:

    i. DWR shall follow all protocols and reporting requirements in the standard operating procedures provided in the BA (U.S. Bureau of Reclamation 2023-2024) for fish screen cleaning and the removal of sediment and aquatic weeds to maintain fish screen functionality at Barker Slough Pumping Plant.

    ii. DWR shall send an annual report to the NMFS California Central Valley Office by December 31 of each year for the previous water year's operations. The report shall contain information regarding the dates of sediment removal or vegetation cleaning, the number of observed fish, including the number of salmonids and sDPS green sturgeon, if any, and the final disposition of the fish. If salmonids are observed, the report shall include the body lengths and run assignments for each fish.

e. DWR shall incorporate the following terms and conditions related to the Aquatic Weed Control Program in CCF:

    i. DWR shall follow all protocols and reporting requirements in the standard operating procedures provided in the BA (U.S. Bureau of Reclamation 2023-2024) for aquatic weed management in CCF.

    ii. DWR shall provide notification of intent to conduct aquatic weed removal activities to NMFS at least 2 weeks prior to starting, including the types of herbicides intended to be used for that application and the areas that will be treated. This includes mechanical and chemical treatments.

    iii. DWR shall send copies of the water quality monitoring results for the concentration of herbicides in the CCF following treatment to NMFS within 10 business days of DWR's receipt of the results.

    iv. DWR shall report to NMFS any fish observed exhibiting unusual behavior or found dead or moribund following herbicide treatment within 10 business days of the incident. All dead specimens shall be retained and NMFS notified for final disposition.

f. DWR shall incorporate the following terms and conditions related to South Delta Agricultural Barriers:

    i. DWR shall provide documentation to NMFS indicating the anticipated schedule for culvert operations, including potential early closures and water elevation conditions, by the completion of barrier installation each

season. Updates to barrier operations shall be provided to NMFS on a weekly basis until mid-June.

6. **The following terms and conditions implement reasonable and prudent measure 6 to minimize the impact of the amount or extent of incidental take of Southern Resident killer whales during operations:**

    a. Reclamation shall monitor and report the change in freshwater survival and subsequent availability of adult listed and non-listed CV Chinook salmon throughout the project area as a result of operations of CVP dams, power plants, diversions, canals, gates, and related federal facilities located on the watersheds of Clear Creek; the Sacramento, American, Stanislaus, and San Joaquin rivers; and CVP and SWP facilities in the Sacramento-San Joaquin Delta and Suisun Marsh and Bay.

        i. If the anticipated reduction in fall or late fall-run juvenile CV Chinook salmon survival is exceeded, Reclamation shall notify NMFS and discuss potential additional mitigation measures or other actions described in the "Fall-run Action Plan."

7. **The following terms and conditions implement reasonable and prudent measure 7 to monitor and report the amount and extent of incidental take to NMFS:**

    a. Reclamation and DWR shall monitor the amount and extent of incidental take through the continued use of programs and processes described in Appendix G: U.S. Fish and Wildlife Service Actions at Federal Fish Hatcheries (National Marine Fisheries Service 2019b, Appendix G). Reclamation and DWR also shall annually maintain and update Appendix G as appropriate to describe the intended monitoring programs and how they will be used to monitor the amount and extent of take, how they will be applied to CVP and SWP water operation decision making and how they will be used for validation and effectiveness monitoring of Collaborative Planning actions.

    b. Reclamation and DWR, to the maximum extent practicable, shall coordinate with the Interagency Ecological Program Biotelemetry Project Work Team to accommodate research that requires special handling of salvaged fish, release of adipose fin-clipped sutured fish, and checking for acoustic tags.

8. **The following terms and conditions implement reasonable and prudent measure 8 to develop conservation measures for CCV steelhead including actions that accelerate steelhead science, develop population-based approaches to minimize entrainment, and minimize entrainment of CCV steelhead into the South and Central Delta and export facilities.**

    a. Within 2 years of the ROD, Reclamation shall develop a CCV steelhead science plan for the Sacramento River basin with a goal of improving the scientific understanding of the CCV steelhead population structure and size and developing a JPE that includes CVP, SWP, and non-CVP or SWP tributaries.

b. Within 5 years, Reclamation and DWR shall have a final CCV steelhead JPE, or other reasonable approach, approved by NMFS, to develop entrainment loss metrics and actions that are scaled to population size.

c. Within 1 year of the ROD, Reclamation and DWR shall develop a hatchery steelhead surrogate and entrainment triggers and actions that shall be in place until a basin-wide JPE is completed.

d. By December 2026, Reclamation and DWR shall complete a study in coordination with NMFS on actions at Head of Old River to reduce the entrainment of San Joaquin River-origin CCV steelhead into Old River and salvage and entrainment (take) at the export facilities.

    i. If the study indicates a measurable reduction in salvage at the pumps related to reduced entrainment into the Head of Old River, Reclamation shall implement a non-physical barrier beginning in the Spring of 2027 and annually thereafter. Implementation may be phased to allow pilot testing of the action and integration with the Head of Old River Scour Hole studies and restoration.

e. By December 2026, Reclamation and DWR shall complete the studies for reducing predation at the Head of Old River Scour Hole.

    i. If the study indicates a measurable reduction in predation, Reclamation shall implement a restoration of the Head of Old River Scour Hole by 2028. The studies should improve the understanding of how this action may integrate with the Head of Old River entrainment action.

9. Reclamation and DWR shall, to the extent feasible and practicable, coordinate implementation of spring pulse flows across divisions through SHOT and WOMT to help improve spring out-migration conditions and Central Valley spring-run Chinook salmon survival.

a. Reclamation and DWR shall use WOMT as a forum for coordinating on pulse flows in the Central Valley, with a goal of aligning the timing to improve in-river flow conditions that improve the survival of out-migrating salmon.

12. REINITIATION OF CONSULTATION

This concludes formal consultation for the Long-Term Operation of the Central Valley Project and State Water Project.

Under 50 CFR 402.16(a): "Reinitiation of consultation is required and shall be requested by the federal agency, where discretionary federal involvement or control over the action has been retained or is authorized by law and: (1) If the amount or extent of taking specified in the incidental take statement is exceeded; (2) If new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not previously considered; (3) If the identified action is subsequently modified in a manner that causes an effect

to the listed species or critical habitat that was not considered in the biological opinion or written concurrence; or (4) If a new species is listed or critical habitat designated that may be affected by the identified action."

13. DATA QUALITY ACT DOCUMENTATION AND PRE-DISSEMINATION REVIEW

The Data Quality Act (DQA) specifies three components contributing to the quality of a document. They are utility, integrity, and objectivity. This section of the opinion addresses these DQA components, documents compliance with the DQA, and certifies that this opinion has undergone pre-dissemination review.

13.1. Utility

Utility principally refers to ensuring that the information contained in this consultation is helpful, serviceable, and beneficial to the intended users. The intended users of this opinion are Reclamation and DWR. Other users could include Public Water Agencies and other interested parties. Individual copies of this opinion were provided to Reclamation and DWR. The document will be available within 2 weeks at the NOAA Library Institutional Repository. The format and naming adhere to conventional standards for style.

13.2. Integrity

This consultation was completed on a computer system managed by NMFS in accordance with relevant information technology security policies and standards set out in Appendix III, 'Security of Automated Information Resources,' Office of Management and Budget Circular A-130; the Computer Security Act; and the Government Information Security Reform Act.

13.3. Objectivity

Information Product Category: Natural Resource Plan

Standards: This consultation and supporting documents are clear, concise, complete, and unbiased; and were developed using commonly accepted scientific research methods. They adhere to published standards including the ESA regulations and 50 CFR 402.01 et seq.

Best Available Information: This consultation and supporting documents use the best available information, as referenced in the References section. The analyses in this opinion contain more background on information sources and quality.

Referencing: All supporting materials, information, data and analyses are properly referenced, consistent with standard scientific referencing style.

Review Process: This consultation was drafted by NMFS staff with training in ESA, and reviewed in accordance with West Coast Region ESA quality control and assurance processes.

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Programmatic Biological Opinion for the Reinitiation of Consultation on the Long-Term Operation of the Central Valley Project and State Water Project 2024

Appendix A:

Bureau of Reclamation's
Long-Term Operation – Biological Assessment, Chapter 3
Proposed Action
October 23, 2024

BUREAU OF RECLAMATION

Long-Term Operation – Biological Assessment

Chapter 3 – Proposed Action

Central Valley Project, California

Interior Region 10 – California-Great Basin

U.S. Department of the Interior November 2023

Mission Statements

The U.S. Department of the Interior protects and manages the Nation's natural resources and cultural heritage; provides scientific and other information about those resources; honors its trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated Island Communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

Chapter 3 – Proposed Action

Central Valley Project, California

Interior Region 10 – California-Great Basin

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Chapter 3 Proposed Action

The United States Department of the Interior, Bureau of Reclamation (Reclamation) operates the Central Valley Project (CVP) for the congressionally authorized purposes of (1) river regulation, improvement of navigation, and flood control; (2) irrigation and domestic uses, and fish and wildlife mitigation, protection, and restoration; and (3) power, and fish and wildlife enhancement. The California Department of Water Resources (DWR) operates the State Water Project (SWP) for the primary purpose of water supply deliveries and flood control, and the SWP provides additional benefits including power generation and environmental stewardship. Public Law 99-546 authorized the 1986 Coordinated Operation Agreement (COA), which sets procedures for Reclamation and DWR to share joint responsibilities for meeting Delta standards and other legal uses. Operation of the CVP and SWP also provides recreation and water quality benefits.

The Proposed Action covers CVP service areas and the operation of CVP dams, power plants, diversions, canals, gates, and related Federal facilities located on the watersheds of Clear Creek; the Sacramento, American, Stanislaus, and San Joaquin rivers; and CVP and SWP facilities in the Sacramento–San Joaquin Delta (Delta) and Suisun Marsh and Bay. Figure 3-1 shows a simplified hydrologic topology and the facilities operated in the Proposed Action.

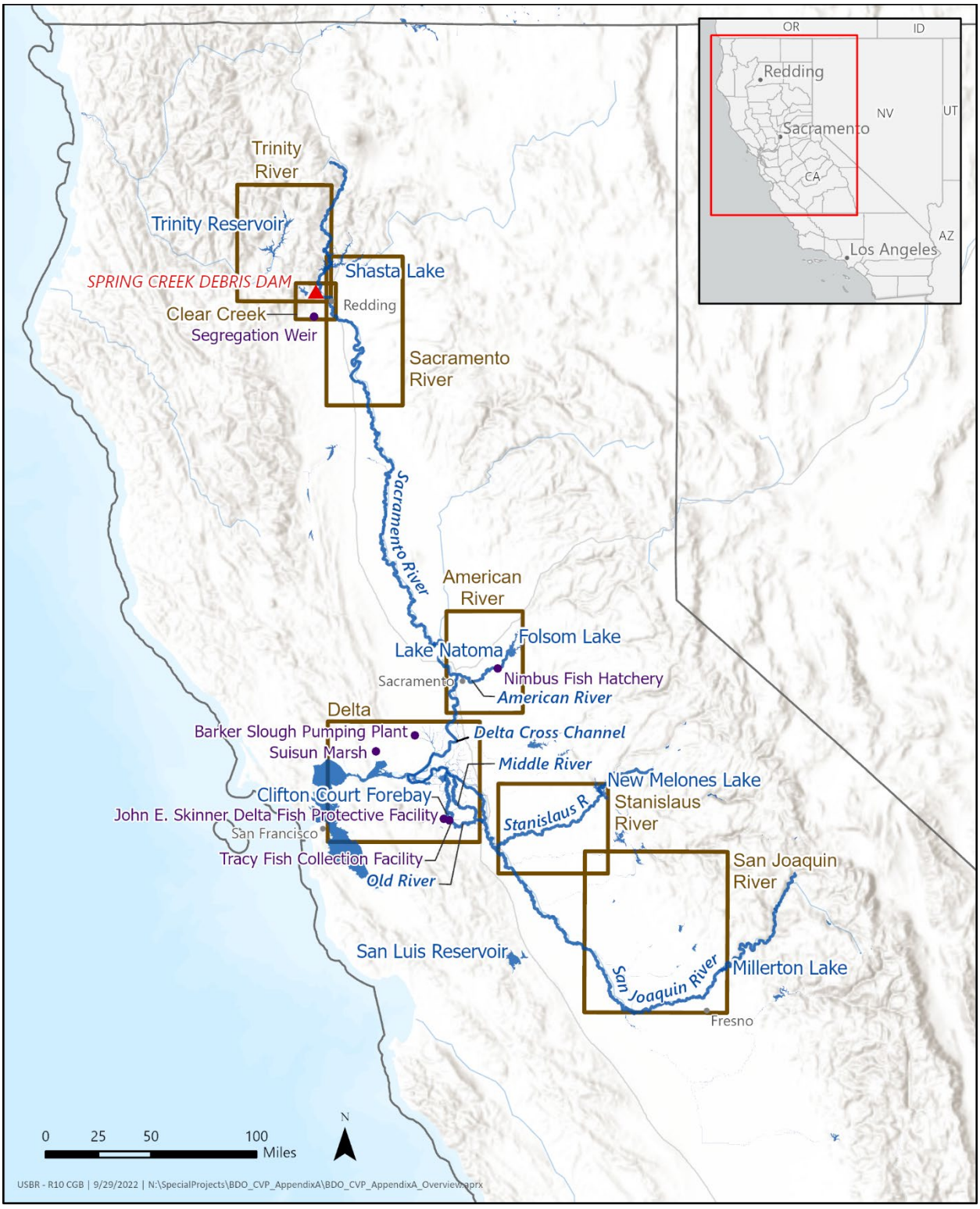


Figure 3-1. Overview of the Facilities Operated in the Proposed Action

Reclamation plans the operation of the CVP by projecting monthly, on a 12-month lookahead cycle, an "operations outlook" for how available water resources can best meet regulatory requirements and water supply purposes, including considerations for public health and safety, wildlife refuges, senior water rights, water quality, fishery needs, other environmental requirements, and water service or repayment contracts. In most years, the combination of storage and runoff into CVP reservoirs and the Central Valley, after meeting statutory requirements, is not enough to fully meet CVP water service contractor demands and shortages occur. The water available for delivery to CVP water service contractors is determined by an administrative process, referred to as "allocations," that considers storage, forecasted inflow, system accretions and depletions, facility limitations, and project requirements under the operations outlook. The estimate of available water supply in the north of Delta system, along with the anticipated quantity of water needed to meet requirements throughout the year (such as State Water Resources Control Board (State Water Board) Water Right Decision 1641 [D-1641]), determine the north of Delta allocations. The estimate of water supply upstream, previously stored water south of the Delta (in San Luis Reservoir), and the potential conveyance capability through the Delta determine south-of-Delta allocations. The Municipal and Industrial (M&I) Water Shortage Policy determines the quantity of water during shortages for M&I and agricultural uses, for those water service and repayment contractors that reference the policy.

No later than February 15, Reclamation makes "Critical Year" determinations for Central Valley Project Improvement Act (CVPIA) wildlife refuges under Refuge Water Supply Agreements and senior water right holders under Sacramento River Settlement Contracts, the San Joaquin River Exchange Contract, and San Joaquin River Settlement Contracts, as described by those contracts and agreements. Depending upon hydrologic conditions, the determination may be updated.

On or about February 20 of each year, Reclamation provides an initial declaration of the water made available under water service contracts, an "Initial Allocation." Water service contracts generally run from March through February. Beginning in February, Reclamation prepares forecasts of water year runoff using precipitation to date, runoff to date, and snow water content accumulation. Reclamation typically updates forecasts of runoff and operations plans at least monthly through May. If the water initially anticipated to be available is no longer likely to be available, Reclamation provides a reduced allocation and notifies the water service contractors that less water will be available for delivery. This approach is generally based on a 90% forecast and is intended to minimize the frequency of drier or warmer conditions than forecasted and avoid situations where a previous allocation for fisheries and agriculture cannot be supported. Reclamation may execute temporary contracts, not to exceed one year, for delivery of an unusually large water supply not otherwise storable or infrequent and otherwise unmanaged flood flows[1]. Reclamation may make water available under the water service or repayment contracts in addition to the allocation and consistent with legal obligations[2]. Under the Accelerated Water Transfer Program, Reclamation may transfer water within counties, watersheds, or other areas of origin without showing it as having been consumptively used or irretrievably lost. Actions to make water available are described in the Seasonal Operations sections for each CVP and SWP facility and modelled to identify changes in river flows.

[1] Section 215 of the Reclamation Act

[2] Paragraph 3(f) of Water Service and Repayment Contracts

DWR similarly plans the operations of the SWP by projecting monthly on a 12-month look-ahead cycle. The initial allocation for SWP deliveries is made by December 1 of each year with a conservative assumption of future precipitation to avoid over-allocating water before the hydrologic conditions are well defined for the year. As the water year unfolds, Central Valley hydrology and water supply delivery estimates (Table A Deliveries) are updated using known information and conservative forecasts of future hydrology. DWR may deliver water that is surplus to Table A Deliveries (Article 21 water). Feather River Service Area contracts provide the terms for DWR to avoid interference with claimed senior water rights on the Feather River.

The Fish and Wildlife Coordination Act and the CVPIA, among others, authorize Reclamation to operate, in part, for fish and wildlife project purposes, undertake projects for habitat restoration and facility improvements, and to improve scientific understanding through developing models and supporting data. Following the 1995 Bay-Delta Accord, Reclamation and DWR operate the CVP and SWP to meet certain water quality control plan requirements for Delta outflow and salinity under D-1641. The responsibilities of DWR and Reclamation for senior water rights on the Sacramento River, Feather River, and in the Delta, as well as other regulatory requirements are allocated by the 2018 amended COA.

The Proposed Action is organized as follows:

- **Watersheds:** basin-by-basin description of facilities and the proposed operation for fish and wildlife, water supply, and power generation including proposed conservation measures to promote the recovery and/or to minimize or compensate for adverse effects of operation on federally listed species.
- **Monitoring:** the long-term evaluation of performance to assess overall effectiveness over time. Although each watershed has unique requirements, Reclamation and DWR integrate monitoring across watersheds; therefore, monitoring is organized in a single section.
- **Special Studies:** science-based efforts to address uncertainties in the Proposed Action that affect a reasonable balance among competing demands for water, including the requirements of fish and wildlife, agricultural, municipal, and industrial uses of water, and power contractors to inform subsequent decision making.
- **Drought:** actions to recognize extreme dry conditions may occur during operations. The boom-and-bust nature of California hydrology and the resulting effect on species warrants special consideration for operation during droughts. Although each drought is unique, contingency planning can facilitate a response.
- **Governance:** ongoing engagement by Reclamation and DWR with U.S. Fish and Wildlife Service (USFWS), National Marine Fisheries Service (NMFS), California Department of Fish and Wildlife (CDFW), interested parties, and the public following completion of Biological Opinions and a Record of Decision.
- **Adaptive Management:** science and decision analytic-based approach to evaluate and improve actions, with the aim to reduce uncertainty over time and increase the likelihood of achieving and maintaining a desired management objective.

Each subsequent watershed section highlights authorizing legislation and requirements under the regulations, contracts, and agreements. Watershed sections identify ongoing efforts in the baseline that mitigate the effects of the operation of the CVP and SWP and for which Reclamation and DWR are not consulting nor reinitiating consultation on as part of this Proposed Action. These programs have existing environmental compliance, agreements, and/or contracts with severable utility. These activities are in the baseline and may mitigate the effects of the operation of the CVP and SWP, some of which have been described in previous consultations and implemented.

3.1 Sacramento River

Reclamation operates and maintains the Shasta Division of the CVP for flood control and navigation, M&I and agricultural water supplies, fish and wildlife, hydroelectric power generation, Sacramento River water quality, and Delta water quality. Facilities include the Shasta Dam and Power Plant, Keswick Dam and Power Plant, and a Temperature Control Device (TCD) on the Upstream face of Shasta Dam. Flood control operations are based on regulating criteria developed by the U.S. Army Corps of Engineers (USACE) pursuant to the provisions of the Flood Control Act of 1944. Flood control requirements reserve up to 1.3 million acre-feet (MAF) of space (flood control pool) behind Shasta Dam, leaving 3.2 MAF of space (conservation pool) for storage management during the winter flood season. Reclamation generally maintains flows of at least 5,000 cubic feet per second (cfs) at Wilkins Slough year-round and these flows may be reduced in low-storage and/or drought years.

Major facilities in the Sacramento Division of the CVP include the Red Bluff Pumping Plant, Tehama-Colusa Canal, and Corning Canal (Figure 3-2). Agricultural deliveries provide for the irrigation of over 150,000 acres of land in Tehama, Glenn, Colusa, and Yolo Counties. The Red Bluff Pumping Plant is the intake for the Tehama-Colusa Canal and the Corning Canal. Water is diverted from the Sacramento River approximately 2 miles southeast of Red Bluff through the 2,500 cfs, screened Red Bluff Pumping Plant. In 2011, Reclamation permanently welded the Red Bluff Diversion Dam gates in the open position.

Imports from the Trinity River Basin (Trinity Division) are delivered to the Sacramento River for downstream needs via two pathways: released from Whiskeytown Reservoir to Clear Creek and joins the Sacramento River at the mouth of Clear Creek south of Redding or delivered to Keswick Reservoir through the Spring Creek Tunnel and Power Plant where water mixes with releases from Shasta Reservoir and is released from Keswick Dam.

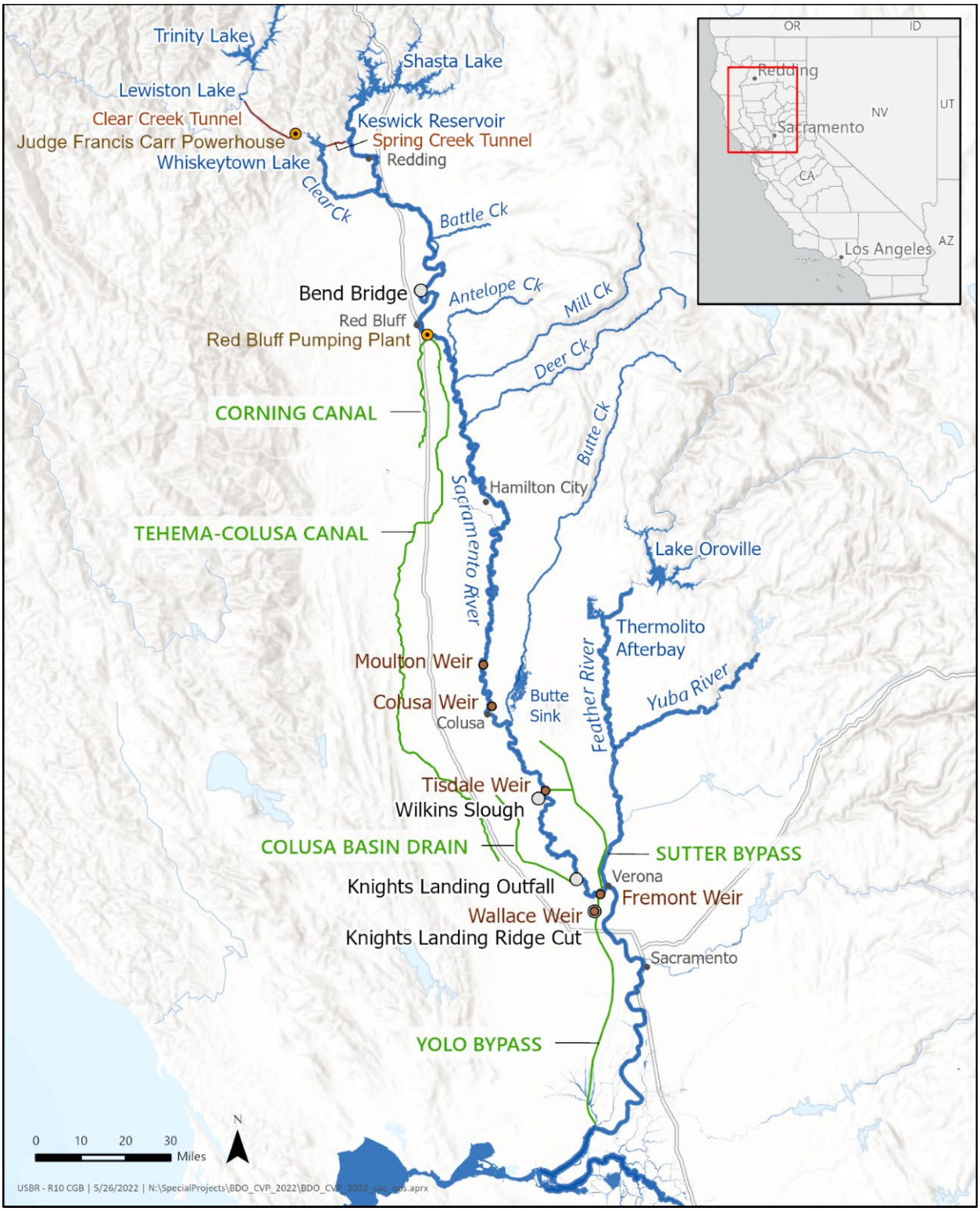


Figure 3-2. Sacramento River Facilities in the Shasta and Sacramento Divisions of the Central Valley Project and Flood Control Weirs and Bypasses

For more information on statutory, regulatory, and contractual requirements, see Appendix A, *Facilities Description*:

- Section 7 of the Flood Control Act of 1944
- Public Law 74-392 CVP Re-Authorization Act
- Public Law 81-839 Sacramento Valley Canals
- Central Valley Project Improvement Act (CVPIA)
- State Water Board Decision 990
- State Water Board Water Rights Order 90-5
- State Water Board Water Rights Order 91-1
- State Water Board D-1641
- Settlement Contracts
- Exchange Contracts
- Water Service Contracts

Programs in the environmental baseline to highlight:

- Spawning and Rearing Habitation Restoration

3.1.1 Seasonal Operations

Reclamation operates Shasta Dam in the winter primarily for flood control and minimum flows in the Sacramento River and in the Delta. With flashboards installed on top of the drum gates that raise the elevation to 1,067 feet, the maximum capacity of Shasta Reservoir is 4.552 MAF. For the flood season, USACE provides a flood control diagram that specifies by date a top of conservation pool storage. Flood operational criteria target flow rates below 100,000 cfs at Bend Bridge for the protection of downstream populations; therefore, reservoir elevations may temporarily exceed the top of the conservation pool and encroach into flood space in order to limit downstream flows. In the winter, when not releasing for flood control, Reclamation seeks to store inflows to Shasta Reservoir and releases the minimum flows necessary to meet downstream requirements. State Water Board Water Rights Order 90-5 provides a target for minimum releases from Keswick Reservoir from September through February, the 1937 Act includes consideration for navigation at Wilkins Slough, and State Water Board D-1641 provides flow standards in the Delta. Reclamation may make releases above the minimum to maintain fall-run Chinook salmon redds in wetter hydrologic year types when storage levels are higher in Shasta Reservoir.

In the spring, when not operating for flood control, Reclamation seeks to minimize releases and store inflow to optimize the filling of CVP reservoirs by the end of the flood control season (end of May). Higher storage improves the ability to meet downstream temperature requirements and increases the ability to make releases later in the year for water supply. Accretions (flows from

non-project creeks into the Sacramento River below Shasta Dam) reduce the need for additional releases from Shasta Reservoir and help to meet both instream demands and Delta outflow requirements. Wetter years with high accretions may allow Reclamation to store water in the spring and operate mostly for flood control. Drier years with lower accretions may require Reclamation to make releases from Shasta Reservoir for downstream requirements throughout the spring season. Toward the middle to end of spring, instream diversion demands increase on the mainstem Sacramento River and require releases above minimums at Keswick Reservoir Reclamation operates to flow objectives at Wilkins Slough to support diversion by Sacramento River Settlement Contractors with a prior entitlement to water in the Sacramento River, for deliveries to CVPIA wildlife refuges, and for deliveries to CVP water service contractors at the Red Bluff Pumping Plant. The majority of these diversions typically occur mid-April through November with variations depending on hydrology.

Delta salinity and outflow requirements may necessitate additional releases from Shasta Reservoir. When system-wide demands require augmenting flows in the system, Reclamation coordinates imports from the Trinity Basin, releases by DWR from Oroville Reservoir, and releases from Folsom Reservoir. Each reservoir has factors to consider including instream requirements, amounts in storage, forecasted inflow, and refill potential. The 2018 COA describes the CVP portion of Delta outflow requirements. Reclamation balances releases for the CVP portion of Delta outflow requirements between Shasta and Folsom Reservoirs to maximize storage in each reservoir and minimize negative impacts between CVP tributaries. When increased releases are necessary to meet delta needs, Reclamation generally first adjusts exports, then releases from Folsom Reservoir while releases from Shasta Reservoir travel down the Sacramento River. Once releases from Shasta Reservoir arrive in the Delta (about 5 days' travel time), releases from Folsom Reservoir can be reduced to balance the demands on each reservoir. When Reclamation can export water from the Delta during periods of excess flow, Reclamation can store more water in San Luis Reservoir south of the Delta. Maximizing exports in the spring reduces the reliance on stored water later in the year for meeting late season demands.

Summer operational considerations include releases for temperature control, to support essential features of designated critical habitat, instream diversion demands, Delta outflows, Delta salinity, and exports. In-river temperatures downstream of Keswick Dam can be controlled via two methods. The first is thermal mass, by changing release volume or shifting releases between Trinity imports and Shasta Reservoir, and the second is selective withdrawal of colder water through the TCD. Determination of which method to use is made daily as operators balance releases from multiple reservoirs to meet downstream needs. Releases in the summer meet temperature objectives, support essential features of critical habitat and support water supply deliveries. Releases from Shasta Reservoir typically begin increasing in April as storm frequency decreases, air temperatures increase and system-wide demands increase. Peak releases from Shasta Reservoir typically occur June through August and begin to decrease from the peak sometime in August or September. Occasionally, in wetter years, high storage levels through the summer may result in a need to release higher than normal flows in early fall to meet flood control requirements for the next water year. Consideration of fall conditions may also warrant measures for drought protection and rebalancing of storage between reservoirs.

In the fall, Reclamation's objective is to reduce Keswick Dam releases and rebuild storage in Shasta Reservoir. Reclamation balances fall operations based on highly variable conditions:

temperature control (dependent on winter-run Chinook salmon emergence timing), maintenance of winter-run redds (dependent on spawning depths), instream diversion demands on the mainstem of the Sacramento River upstream and downstream of Wilkins Slough (dependent on seasonal planting and wildlife refuges), minimizing fall-run Chinook salmon redd dewatering (dependent on late-summer flows and fall spawning timing), and stabilizing releases through fall-run Chinook salmon egg and alevin incubation. The remaining coldwater pool in Shasta Reservoir is usually limited in the fall at the end of the temperature management season. Release reductions from Shasta Reservoir early in the fall consider that some winter-run Chinook salmon eggs and alevin are still incubating, significant instream diversion demands (e.g., rice decomposition) remain on the mainstem of the Sacramento River between Keswick Dam and Wilkins Slough and, depending on conditions, Delta requirements may require upstream reservoir releases for Delta outflow under requirements from the State Water Board or for Delta smelt habitat. If early fall flows drop substantially after fall-run Chinook salmon spawn at high river stages, their redds may be dewatered when flows are later reduced to rebuild storage.

Seasonal Operations will be managed by Reclamation in coordination with the Shasta Operations Team (SHOT), following the monthly SHOT Planning and Actions.

3.1.2 Sacramento River and Shasta Reservoir Coordination Forums

Governance is described in detail in Section 3.13, *Ramping Rates*, which includes group members, protocols, meeting frequencies, decision making approaches and other details. For the Sacramento River and Shasta Reservoir, three main coordination forums will meet regularly to discuss seasonal and real-time operations. These include the Winter-run JPE SubTeam, Sacramento River Group (SRG) and the SHOT. The Winter-run JPE SubTeam is a technical group tasked with development of the winter-run juvenile production estimate (JPE) each year and the winter-run broodstock assessment. It is composed of technical staff from Reclamation, DWR, NMFS, USFWS, and CDFW. The SRG is a technical group to discuss pulse flow shaping, temperature management, fall flow smoothing and fall/winter base flows. It is composed of technical staff from Reclamation, DWR, NMFS, USFWS, CDFW, Sacramento River Settlement Contractors (SRSCs), WAPA, the State Water Board, and Native Tribes. The SHOT is a policy level group that discusses the actions described in this Proposed Action when implementation may have biological, system conditions or water supply impacts or tradeoffs. It is composed of management and policy staff from key management agencies including the SRSCs. Generally, topics will be discussed at a technical level through SRG with agency feedback provided prior to being discussed at the SHOT. Each action below briefly describes the coordination process within these two groups prior to Reclamation making decisions that have risks, impacts and tradeoffs. For the matters listed below, Reclamation requests NMFS, USFWS and CDFW provide technical assistance along with the other members through these groups.

3.1.3 Ramping Rates

Rapid changes in river elevation from ramping reservoir releases up or down can impact aquatic biota. Sudden flow decreases can strand fishes and macroinvertebrates. Ramping rates to limit how quick releases are reduced can lessen or minimize these impacts. Under Order 90-5, the release rate (ramping) from Keswick Dam from September through February shall not decrease more than the following rates to minimize stranding of salmon.

- Releases shall not be decreased more than 15% in a 12-hour period

- Releases shall not be decreased more than 2.5% in a 1-hour period

In addition to the requirements under Order 90-5, ramping rates for Keswick Dam between July 1 and March 31 would be reduced between sunset and sunrise.

- Keswick Dam releases >6,000 cfs, reductions in releases may not exceed 15% per night, and no more than 2.5% per hour
- Keswick Dam releases 4,000 cfs to 5,999 cfs reductions in releases may not exceed 200 cfs per night, or 100 cfs per hour
- Keswick Dam releases between 3,250 cfs and 3,999 cfs; reductions in releases may not exceed 100 cfs per night

Reclamation after coordination through the SHOT, may make deviations from this ramping rate to provide incremental benefits to fish species. Such deviations would be initially discussed through the SRG prior to coordination through the SHOT.

3.1.4 Fall and Winter Baseflows for Shasta Refill and Redd Maintenance

Fall and winter base flows support fall- and spring-run Chinook salmon, address winter-run Chinook salmon redd dewatering stressors, and support cold water pool management. Reclamation will operate to a consistent fall and winter baseflow between December and February unless additional releases are necessary for meeting downstream purposes. Consistent minimum flows are intended to avoid unintentional dewatering, support aquatic habitat, and avoid other impacts from regular flow fluctuations. Targets for fall and winter base flows (December 1 through the end of February) from Keswick would be set in October based on Shasta Reservoir end-of-September storage and the current hydrology. Base flows will range from 3,250 cfs to 5,000 cfs (Table 3-1). Each year, the base flow will be set to balance between the risk of required storage management or flood control releases in the coming fall and winter with supporting refill capabilities for Shasta Reservoir to build cold water pool for the following year.

Table 3-1. Keswick Dam December through February Default Release Schedule determined by End-of-September Storage

Keswick Release (cfs)	Shasta End-of-September Storage (MAF)
3,250	≤ 2.4
4,000	≤ 2.8
4,500	≤ 3.2
5,000	> 3.2

cfs = cubic feet per second; MAF = million acre-feet

Reclamation, after coordination through the SRG and SHOT, will determine the schedule for release reductions as well as any deviations from this default table by developing a risk analysis that relies on real-time fish monitoring data, winter-run redds remaining in the river, fall-run

returns, expected fall water deliveries and transfers. Based on this analysis and the coordination through SRG and SHOT, Reclamation may delay or extend the ramp down to minimum fall and winter flows for the benefit of the fish populations. Such a delay will be coordinated through SRG and SHOT in light of the expected tradeoffs between minimizing winter-run redd dewatering, building storage for the next water year for temperature management and minimizing fall-run stranding and redd dewatering later in the fall. When higher storage exists at the end of September, but the fall hydrology is dry (generally defined as below 90% exceedance of historical hydrology), Reclamation, after coordination through the SRG and SHOT, may reduce flows below those described in the table (or as modified by the risk analysis), if beneficial for fish populations and to building storage for the following year.

This approach to selecting fall, winter, and spring minimum flows allows Reclamation to build and conserve storage for supporting cold water pool management and summer demands. Data indicating that the flood control curve will be reached in December may result in flood control releases over the minimum flows, typically in the December through May period. Low minimum flows in the fall and winter period directly increases the likelihood and magnitude of the flood control releases in the winter and spring months.

In order to minimize the risk of juvenile stranding and redd dewatering during the fall season, to the extent possible given Reclamation's other legal and contractual obligations, Reclamation will coordinate with the SRG to consider planned summer flows that are smoothed out to minimize the net difference between the flow at spawning versus emergence.

3.1.5 Minimum Instream Flows

Under certain hydrologic circumstances during fall and winter months, side flows from creeks within and around the City of Redding may experience short term periods of high flows in response to major storm events. Reclamation, after coordination through the SRG and SHOT, and also through adaptive management, may temporarily reduce Keswick Dam releases below 3,250 cfs to preserve storage, as long as flows at the SAC CDEC gage maintain a minimum 3,250 cfs throughout that Keswick Dam flow reduction.

3.1.6 Rice Decomposition Smoothing

Rice decomposition smoothing could minimize impacts to fall-run Chinook salmon by minimizing fry stranding and redd dewatering as flows drop in the winter. Reclamation will release flows based on Sacramento Valley Water Service Contractors demand and Sacramento River Settlement Contractors coordinated rice decomposition smoothing diversion schedule. Sacramento River Settlement Contractors and CVP Water Service Contractors will synchronize their diversions to lower peak rice decomposition demand. Starting in August, Reclamation and the Sacramento River Settlement Contractors, through the SRG, will develop a delivery schedule based on dewatering risk for winter-run redd locations. The delivery schedule will be updated as conditions warrant.

3.1.7 Sacramento River Pulse Flows

To increase outmigration survival of Chinook salmon, Reclamation would release up to 150 thousand acre-feet (TAF) in pulse flow(s) each water year, typically in the spring, to benefit Chinook salmon in the Sacramento River watershed when the pulse does not interfere with the ability to meet temperature objectives or other anticipated operations of the reservoir.

Reclamation will schedule this pulse after coordination through the SRG and SHOT and may include coordinating timing with natural flow events, potential storage management operations and/or pulse flows in tributaries.

The timing, magnitude, duration, and frequency of the pulse flows will be refined through the SRG to maximize multi-species benefits, which may include coordinating timing with natural flow events, potential storage management operations, potential SRSC demands and infrastructure limitations, and/or pulse flows in tributaries or reducing the volume of the pulse flow. The pulse flow volume and schedule will be developed through the SRG and provided to the SHOT. Reclamation, through the SHOT, will discuss the plan and make any appropriate and/or necessary refinements prior to implementation.

The VA flow assets may contribute to augmenting a pulse flow. Under conditions when the pulse flow is reduced or not released due to potential impacts on temperature management or other project purposes, the VA flow assets may be used to meet part or all of the pulse flow action. In certain cases, it may be most beneficial to release both the pulse flow and the VA asset together to provide the best benefit to the species.

3.1.8 Adult Migration and Holding Temperature Objectives

Spring temperatures can impact winter-run adults in multiple ways (gamete viability, spawning initiation, temperature shock, adult migration, disease risk, interaction with thiamine deficiency) as well as Late fall-run (impacts to redds). Water temperatures in the March through May period (prior to the start of the typical temperature management season) are typically well under any thresholds of concern for adult migration and adult holding. It is possible that high air temperatures and/or an intentional warm-water power bypass could cause warmer temperatures than normal and may require additional protective measures. Under a circumstance where these conditions may cause water temperatures to rise to concerning levels prior to the final temperature management plan, Reclamation will begin temperature management as early as March 1st to target water temperatures of 58.0° F daily average at the Sacramento River above Clear Creek gage (CCR).

Reclamation, through the SRG and SHOT, may propose a different temperature based on potential impacts to winter-run Chinook salmon spawning and egg incubation in the developing temperature management plan. Section 3.14, *Adaptive Management*, includes a proposal to look more closely at these pre-spawning temperature objectives and may eventually refine the standard.

Additional details on a potential warm-water power bypass to aid in temperature management are included in the drought tool kit and described further in the drought operations priority framework.

3.1.9 Water Temperature and Storage Management

Shasta Reservoir is the largest reservoir in the CVP and the State of California. It is relied upon for meeting multiple and often competing objectives throughout the State but with limited ability to meet these objectives in drought years. In general, the approach to managing Shasta, as with all CVP reservoirs, is to best meet all the authorized purposes of the reservoir while limiting high flow, or flood control, releases where possible to maximize the beneficial use of inflow and

provide flood protection for the Sacramento River and surrounding area. As climate change has been affecting the hydrology and meteorology, the drought periods have become more severe with significantly less inflow as in previous droughts, higher evaporation and evapotranspiration due to increased temperature and more extreme hydrological and meteorological events. In addition, the viability of critically endangered species and other salmon populations that rely on the Sacramento River are not improving due to multiple stressors and are being significantly impacted by these extreme events, particularly the lack of available water (including cold water) in droughts and high air temperatures.

In order to recognize and adapt to these significant changes to the system as a whole, Reclamation is proposing a new approach to managing Shasta which changes the balance between risks of flood control releases (aka spills) and maintaining water in storage for future drought protection and temperature management. This approach, described below, places a higher priority on maintaining storage for drought protection for all project purposes while limiting the frequency of spilling water due to flood control limitations. Reclamation is committed to support a separate Winter-Run Action Plan with NMFS, FWS, CDFW, DWR and SRSCs to pursue a science and monitoring plan, winter-run habitat and infrastructure actions, and water operations. For this Proposed Action, Reclamation is consulting on the water operations of CVP facilities in the Shasta and Sacramento Division of the CVP.

The following sections describe the management framework for the *Plan for Shasta Reservoir Management* (Shasta Management Plan) and drought protection; an annual winter-run broodyear assessment that influences Livingston Stone National Fish Hatchery (LSNFH) decision making, the monthly actions that will be considered by the SHOT; the temperature objectives for winter-run Chinook salmon holding, spawning, egg development and early rearing downstream from Shasta and Keswick Reservoirs; and the process for developing an annual temperature management plan.

3.1.10 Water Temperature and Storage Framework

The goals of the Shasta Management Plan are to provide increased drought protection and maximize suitable temperature regimes for the critically endangered Sacramento River Winter-run Chinook salmon. The Shasta Management Plan considers drought protection actions in nearly every year and identifies actions that will protect storage for multiple project purposes including temperature management. A key principle of the Shasta Management Plan is that drought protection and fish protections are linked. The strategy is framed around an objectives-based management framework adapted from the multi-year drought sequence experienced in Victoria, Australia (Mount et al. 2016, “Victorian Objectives”) that establishes different objectives depending on hydrologic conditions and identifies actions that can be taken for fishery management and drought protection. The general premise is that when hydrologic conditions are good and water resources are available to meet demands they are managed to improve species conditions, which follows the ENHANCE category in Mount et al. 2016, when hydrologic conditions are moderately limited and not available to meet all demands they are managed to RECOVER and MAINTAIN species conditions, and when hydrologic conditions are constrained and the system is stressed they are managed to PROTECT species conditions.

The Shasta Management Plan proposes to integrate Sacramento Basin flow and non-flow measures that are part of the Voluntary Agreements (VAs) to update and implement the Bay-

Delta Water Quality Control Plan. These measures are further described in Section 3.7.5, *Spring Delta Outflow*. The VAs offer a watershed-wide approach that includes new flows, habitat restoration, and a governance and science program that would be deployed adaptively. Specifically, under the VAs, flow and non-flow actions covered under this Proposed Action are not intended to conflict with the State Water Board's Narrative Salmon Objective of the Narrative Viability Objective once adopted.

3.2 Framework Approach

The framework establishes management "Bins" to manage water temperature and storage to meet the Victorian Objectives described above. The framework includes three Bins that are each divided into two categories: standard (Bin A) and drought protection (Bin B). The Bin number (1, 2 or 3) is defined by the projected end of April storage which is primarily driven by hydrology. The letter of the Bin (A or B) is primarily driven by the expected demands on the reservoir which are a function of hydrology, meteorology, system-wide conditions, contractual requirements and other conditions. The A Bins are years when the expected demand from the reservoir is lower meaning it's likely to result in better drought protection should the following year be dry. The B-bins are intended to increase the priority of storage conservation to address the risk that the ensuing year could be a drought. B-bins may be conditions where there is limited water supply in the Shasta system or the system as a whole is more stressed and additional actions are necessary to reach the objectives of that bin. A stressed system is typically indicated by multiple reservoirs across the CVP and SWP having below average storage with below average hydrology either seasonally or in a particular month. Bin assignments will begin in February and will be updated monthly as needed through mid-April. Adjustments after April will be made as appropriate based on changes in hydrology and through coordination with the SHOT. The approach establishes biological objectives for each Bin and identifies potential actions based on forecasted End-of April (EOA) storage and forecasted End-of September (EOS) storage indicators.

Based on the outcome of the broodyear assessment prepared by the Winter-run JPE sub-team, Reclamation, NMFS, FWS and CDFW will convene appropriate technical staff to make recommendations if it is necessary to increase the production of winter-run Chinook salmon associated with the Integrated-Recovery Supplementation Program or take other actions to protect production of winter-run Chinook salmon at the LSNFH. FWS, through coordination with the SHOT, will implement measures as appropriate. The outcome of the broodyear assessment may also be considered in implementing actions within the Drought Toolkit as described in Section 3.12.

During any of the Bins described below, Reclamation may request that the Sacramento River Settlement contractors employ some of their voluntary actions identified in their resolution in Section 3.4, *Sacramento River Settlement Contractor Resolution*, to help improve temperature management and/or protect against winter-run redd dewatering and fall-run stranding. If requested, these actions would be implemented in a manner that does not impact the ability of the SRSC to divert per their contract and would be discussed through SHOT with final decision making by the SRSC. These actions include:

- Delaying or shifting spring diversions to maximize storage

- Shifting timing of delivery of transfer water
- Smoothing of fall rice decomp flows

In addition, the SRSCs are expected to have an action under the VA to make water available for the purposes of benefiting aquatic species in the upper Sacramento River and increasing delta outflow. This action may occur in any Bin and is more likely to occur in Bins 1 or 2. Decisions on Shasta-related VA flow assets would be managed through SHOT, as described in Governance in Section 3.13, *Governance*.

Reclamation recognizes that some years may indicate (using a conservative forecast) a 0% CVP north of delta agricultural allocation early in the year (primarily February and March) even though a non-zero allocation is expected in the coming months as the hydrology solidifies. This may be due to late precipitation, lower storage from the previous year or higher regulatory requirements. In some cases, this 0% early allocation could have detrimental impacts to agricultural lands due to the gap in available supplies between the previous contract year (which ends in February) and when transfer water may become available (in April). In consideration of these unique years, Reclamation will consider providing an allocation by mid-February for 3-30 TAF to avoid these significant agricultural impacts while also maintaining the goals of the Proposed Action and not risking a Bin 3 year. Whether or not this allocation maintains the goals of the Proposed Action will be determined through discussions with the SHOT. The SHOT may discuss the expected risks with the relevant contractors to determine the appropriate volume to evaluate and may choose to support an incremental allocation between February and March as more information is received. Should the SHOT determine that even the minimum allocation of 3 TAF cannot be made while meeting the goals of the Proposed Action and/or risks the potential of a Bin 3 year, then the 0% allocation will remain.

3.2.1 Bin 1 – Enhance – ~80% of years

Under Bin 1, hydrologic conditions are generally good and water resources are available to meet demands. Generally, EOA Shasta Reservoir storage is forecasted to allow use of the upper gates of the temperature control device (TCD) to preserve the colder water for later in the season when air temperatures are much higher. This bin begins with an EOA storage forecasted at least 3.7 MAF with a possible storage increase in May and/or June. Bin 1 typically comes with a high confidence to meet cold water temperatures for winter-run Chinook salmon downstream from the Clear Creek gage and to meet drought protection objectives of at least 2.4 MAF EOS storage. In these years, the primary management objectives are to target 53.5F at a location downstream of CCR to maximize suitable habitat for winter-run Chinook salmon and to look for water supply neutral opportunities throughout the system to improve Shasta carryover storage for future year drought protection.

During Bin 1 years, Shasta may be operated to meet a variety of different demands. During the typical irrigation season (April through September), when Wilkins Slough is controlling and there is flexibility to have a Wilkins Slough flow below 5,000 cfs, Reclamation will discuss the appropriate minimum Wilkins Slough flow with the SHOT to ensure flows can both meet biological goals and objectives while also meeting obligations to senior water right holders under the Sacramento River Settlement Contracts. Expected monthly average Keswick and Wilkins Slough flows for these types of years are shown below for reference. October flows may vary

due to demands, water transfer operations and protection of winter-run Chinook salmon redds and are likely to be in the 5,000-7,000 cfs range although higher flows may be necessary at times. Flows beyond these ranges will be discussed through the SHOT with a comparison of expected biological and storage tradeoffs including the potential for these higher flows to increase the likelihood of a bin 2 year the following year. Due to the higher storage that defines Bin 1, it is unlikely that higher releases would result in a Bin 3 year the following year.

- **Bin 1A—**Bin 1A is typically a result of a good water year where the system is not stressed, and additional water management actions are not necessary to achieve an EOS storage of at least 3.0 MAF. Bin 1A is defined as having an end of April storage at or above 3.7 MAF and a projected end of September storage of at least 3.0 MAF. In these years, the primary management goal is to target 53.5F at a location downstream of CCR to maximize suitable habitat for winter-run chinook salmon. The SHOT will discuss tradeoffs of establishing downstream temperature locations that support the biological goal of maximizing suitable habitat and the risk of running out of cold water. As discussed in previous sections, minimum fall and winter flows would be expected to be in the 4,000 – 5,000 cfs range to provide increased fall run habitat or higher if needed for storage management. Bin 1A is defined as having an end of April storage at or above 3.7 MAF and a projected end of September storage of at least 3.0 MAF. As discussed above, this EOA storage ensures good temperature management through providing access to using the upper gates of the TCD and the EOS storage provides a high likelihood of EOA storage greater than 3.7 MAF the following year. An EOS storage of 3.0 MAF along with the higher fall/winter minimum flows also limits the high potential for fall/early winter flood control releases, although these releases are still expected to occur under wetter hydrology.
- **Bin 1B—**Bin 1B is typically a result of a good water year but the system may be slightly stressed, or the water supply may be less than what is seen under Bin 1A. Bin 1B is defined as having an end of April storage at or above 3.7 MAF and a projected end of September storage of at least 2.4 MAF. Consistent with Bin 1A years, this EOA storage ensures good temperature management through providing access to using the upper gates of the TCD. The EOS storage of 2.4 MAF provides a high likelihood of EOA storage greater than 2.8 MAF the following year which is a point at which biological impacts from higher temperatures start to increase significantly. An EOS storage of 2.4 MAF along with the higher fall/winter minimum flows also lessens the potential for fall/early winter flood control releases, although these releases are still expected to occur under wetter hydrology. Similar to Bin 1A, Reclamation, through coordination with SRG and the SHOT, will analyze tradeoffs of establishing downstream temperature locations that support the biological goal of maximizing suitable habitat and the risk of running out of cold water. Reclamation will consider light system tradeoffs for supporting higher Shasta storage (up to 3.0 MAF) with minimal impacts to other parts of the system during their monthly forecasting process. If there are tradeoffs with higher impacts that should be considered to meet the Bin 1 Shasta EOS storage range, Reclamation will consider these through coordination with the SHOT. Available actions primarily include rebalancing between other CVP reservoirs while maintaining all operational goals. If available actions result in storage of 2.4-3.0 MAF, then no further actions would be pursued. If available

actions are not sufficient to result in a storage of at least 2.4 MAF, then this year would be reclassified as Bin 2A.

- **Operational Goals and Objectives**
    - Maintain sufficient storage for drought protection should the next year be dry
    - Limit early season October through December spill
    - Deliver available water while meeting regulatory requirements and obligations to senior water right holders under the Sacramento River Settlement Contracts
- **Biological Goals and Objectives**
    - Victorian objective: Enhance and Recover
    - Maximize species recruitment opportunities
    - Increase spatial diversity
    - Maximize floodplain linkages
    - Enhance ecological flows
    - Manage winter-run spawning habitat downstream from CCR to average daily water temperature of 53.5
    - Targeted Resulting Temperature Dependent Mortality to be ≤3%
    - When necessary, manage adult holding temperatures to a daily average temperature no higher than 58dFto minimize pre-spawning mortality
    - Increase available habitat for fall-run chinook salmon in the fall and winter months
    - Appropriate reach-specific survival objectives will be developed through the Winter-Run Action Plan
- **Bin 1A Operational Goals and Indicators**
    - February, March and April forecasts project ≥ 3.7 MAF EOA storage based on 90% exceedance, or other conservative approach
    - February, March and April forecasts projects ≥ 3.0 MAF EOS storage based on 90% exceedance, or other conservative approach
- **Bin 1B Operational Goals and Indicators**
    - Hydrologic Goal: Initiate drought protection
    - February or March forecasts project ≥ 3.7 MAF EOA storage based on 90% exceedance
    - February or March forecasts project ≥ 2.4 MAF EOS storage based on 90% exceedance

- The goal of actions is to increase projected EOS storage above 2.4 MAF. If this is not possible, shift to Bin 2A

3.2.2 Bin 2 – Recover and Maintain - ~11.5% of years:

Under Bin 2, hydrologic conditions are more limited than in Bin 1 and adequate water resources are not available to meet all demands. Generally, the upper end of the EOA storage is showing upper gates may be used temporarily and even when not, there is high confidence to meet cold water temperatures at the Clear Creek (CCR) gage for the critical development periods of the temperature management season and to meet some drought protection objectives that prevent critical storage levels at the end of September and in the subsequent year. Shasta management actions in this Bin would have light to moderate reductions in water supply or require light to moderate adjustments to system management.

During Bin 2 years, Shasta may be operated to meet a variety of different demands. During the typical irrigation season (April through September), when Wilkins Slough is controlling and there is flexibility to have a Wilkins Slough flow below 5,000 cfs, Reclamation, through coordination with the SRG and SHOT, will identify the appropriate minimum flow to ensure flows can both meet biological objectives while also meeting obligations to senior water right holders under the Sacramento River Settlement Contracts. Expected monthly average Keswick and Wilkins Slough flows for these types of years are shown below for reference. October flows may vary due to demands, water transfer operations and protection of winter-run redds and are likely to be in the 5,000-7,000 cfs range although higher flows may be necessary at times. Reclamation expects to begin ramping down to the minimum flow of 3,250 cfs as described above in late October or early November. Reclamation, through coordination with the SRG and SHOT, will determine when to begin this ramp down after discussing the tradeoffs between storage, next year's temperature management, winter-run redd dewatering and fall run stranding and redd dewatering. Flows or timing outside all ranges described above will be discussed through the SHOT with a comparison of expected biological and storage tradeoffs including the potential for these higher flows to increase the likelihood of a bin 2 or bin 3 year the following year. Should the following year be a Bin 3 year which, in part, was due to releases higher than these expected ranges, these higher flows may limit the available actions to conserve storage in that year.

- **Bin 2A—**Bin 2A is a drier water year and can be the start of a multi-year drought sequence or a single year within a multi-year drought sequence. Bin 2A is defined as having an end of April storage at or above 3.0 MAF and a projected end of September storage of at least 2.2 MAF. This EOA storage does not typically allow full use of the TCD, but, when combined with the EOS of 2.2 MAF, is expected to be adequate to provide sufficient temperatures during the majority of the winter-run spawning and egg incubation period to avoid high temperature-related biological impacts. An EOS storage of 2.2 MAF provides a high likelihood of exceeding an EOA storage of 3.0 MAF the following year and has a low potential for fall/early winter flood control releases, although these releases may still occur under wetter hydrology. In these years, the primary management goals are to target meeting 53.5F at CCR during the winter-run spawning and egg incubation period and to manage water supply to support a carryover that provides some drought protection. The temperature management objectives may be

shaped through SRG and SHOT based on forecasted and/or real-time meteorologic and hydrologic conditions and best available science. Reclamation will consider water supply (CVP allocation) reductions and, through coordination with the SHOT, will identify moderate system-wide tradeoffs and potential transfer modifications with the goal of meeting both of these temperature and storage goals. Moderate system wide tradeoffs general include, but are not limited to, rebalancing between other CVP reservoirs with moderate impacts to other parts of the system. If available actions result in storage of 2.2-2.4 MAF, then no further actions would be pursued. If available actions are not sufficient to result in a storage of at least 2.2 MAF, then this year would be reclassified as Bin 2B.

- **Bin 2B—**Bin 2B is typically a drier water year and can be the start of a multi-year drought sequence or a single year within a multi-year drought sequence. Bin 2B is defined as having an end of April storage at or above 3.0 MAF and a projected end of September storage of at least 2.0 MAF. This EOA storage does not typically allow full use of the TCD, but, when combined with the EOS of 2.0 MAF, is expected to be adequate to provide sufficient temperatures during the majority of the winter-run spawning and egg incubation period to avoid high temperature-related biological impacts. An EOS storage of 2.0 MAF provides a high likelihood of exceeding an EOA storage of 2.8 MAF the following year and has a low potential for fall/early winter flood control releases, although these releases may still occur under wetter hydrology. In these years, the primary management goals are to target meeting 53.5F at CCR during the winter-run spawning and egg incubation period and to manage water supply to support a carryover that provides some drought protection. The temperature management objectives may be shaped through coordination with SRG and SHOT based on forecasted and/or real-time meteorologic and hydrologic conditions and best available science. Reclamation will consider water supply (CVP allocation) reductions and, through coordination with the SHOT, will identify moderate system-wide tradeoffs and potential transfer modifications and with the goal of meeting both of these goals. Moderate system wide tradeoffs generally include, but are not limited to, rebalancing between other CVP reservoirs with moderate impacts to other parts of the system, transfer timing modifications, situation-specific adjustments to Delta water quality standards under D-1641 to address developing drought conditions and other actions from the Drought Toolkit. If available actions result in an EOS storage of 2.0-2.2 MAF, then no further actions would be pursued. If available actions are not sufficient to result in an EOS storage of at least 2.0 MAF, then this year would be reclassified as Bin 3.

- **Operational Goals and Objectives**
    - Maintain sufficient storage for drought protection should the next year be dry
    - Limit early season October through December spill to the extent possible
    - Deliver available water while meeting regulatory requirements and obligations to senior water right holders under the Sacramento River Settlement Contracts
- **Biological Objectives**
    - Victorian objectives: Recover (Bin 2a) and Maintain (Bin 2b)

- Maintain or maximize species recruitment opportunities with some reduction in spawning habitat compared to Bin 1
- Maintain or restore river function and key floodplain linkages
- Restore key ecological flows
- Manage the majority of winter-run spawning habitat at CCR to average daily water temperature of 53.5° F
- Targeted Resulting Temperature Dependent Mortality to be ≤3%
- Manage adult holding temperatures to 58° F to minimize pre-spawning mortality
- Appropriate reach-specific survival objectives will be developed through the Winter-Run Action Plan

- **Bin 2A Operational Goals and Indicators**
  - February or March forecasts project 3.0-3.7 MAF EOA storage based on 90% exceedance or other conservative approach
  - February or March forecasts project 2.2-2.4 MAF EOS storage based on 90% exceedance or other conservative approach
  - The goal of actions is to increase projected EOS storage above 2.2 MAF. If this is not possible, shift into Bin 2B
- **Bin 2B Operational Goals and Indicators**
  - Hydrologic Goal: Increase drought protection
  - February or March forecasts project 3.0-3.7 MAF EOA storage based on 90% exceedance or other conservative approach
  - February or March forecasts project 2.0-2.2 MAF EOS storage based on 90% exceedance or other conservative approach
  - The goal of actions is to increase projected EOS storage above 2.0 MAF. If this is not possible, shift into Bin 3A

3.2.3 Bin 3 – Protect - ~8.5% of years

Under Bin 3, critically dry conditions exist, the system is stressed, and water resources are not available to meet all demands. There is low confidence to meet sufficient temperatures at the Clear Creek gage and future drought protection is at risk. The main biological objective is to protect winter-run Chinook salmon against decline. This Bin includes the widest array of potential water supply and fishery management actions to protect winter-run Chinook salmon from significant impacts and to protect against future drought risks.

During Bin 3 years, Shasta is expected to be operated primarily for meeting public health and safety (including salinity management in the Delta), obligations to senior water right holders under the Sacramento River Settlement Contracts and minimum instream flows. The extent to

which Shasta is relied upon to meet these demands depends on both hydrology and available water in other parts of the system. During the typical irrigation season (April through September), when Wilkins Slough is controlling releases from Keswick, Reclamation, through coordination with the SHOT, will identify the appropriate minimum Wilkins Slough flow to ensure flows can both meet biological goals and objectives while also meeting obligations to senior water right holders under the Sacramento River Settlement Contracts. As a default, Reclamation will target a minimum flow of 3,400 cfs under these conditions. October flows may vary due to demands, water transfer operations and protection of winter-run redds and are likely to be in the 3,250 – 5,000 cfs range although higher flows may be necessary at times. After the irrigation season, Reclamation expects to begin ramping down to the minimum flow of 3,250 cfs as soon as possible given deliveries, delta conditions and winter-run redd dewatering concerns. Reclamation, through coordination with the SHOT, will determine the appropriate ramp down date after evaluating tradeoffs between storage, next year's temperature management, winter-run redd dewatering and fall run stranding and redd dewatering. Should the following year be a Bin 3 year which, in part, was due to releases higher than these expected ranges, these higher flows may limit the available actions to conserve storage in that year.

- **Bin 3A—**Bin 3A is an unusual year type where the hydrology is generally drier, but with a wetter spring or heavy snowmelt based inflow with lower demands expected. Bin 3A is defined as having an end of April storage below 3.0 MAF and a projected end of September storage greater than 2.0 MAF. This EOA storage does not allow full use of the TCD and is unlikely to meet sufficient temperatures at CCR. In these years, the primary management goals are to conserve storage and operate the TCD to target 53.5 F upstream of CCR for the most critical period during the winter-run spawning and egg incubation period to avoid critical loss of winter-run population. Reclamation will reduce Shasta releases for water supply (CVP allocations) to conserve storage with the goal of meeting the EOS storage objective of 2.0-2.2. Reclamation, through coordination with the SHOT, will identify moderate system-wide tradeoffs and potential transfer modifications with the goal of conserving storage and meeting temperature objectives. Moderate system wide tradeoffs generally include, but are not limited to, rebalancing between other CVP reservoirs with moderate impacts to other parts of the system, transfer timing modifications, situation-specific adjustments to Delta water quality standards under D-1641 to address developing drought conditions and other actions from the Drought Toolkit. If available actions result in storage of 2.0-2.2 MAF, then no further actions would be pursued. If available actions are not sufficient to result in a storage of at least 2.0 MAF, then this year would be reclassified as Bin 3B.
- **Bin 3B—**Bin 3B is typically a dry water year and is often within a series of drier years such as during a multi-year drought sequence. Bin 3B is defined as having an end of April storage below 3.0 MAF and a projected end of September storage less than 2.0 MAF. An EOA storage below 3.0 MAF combined with an EOS storage of below 2.0 MAF will make protective temperature management very challenging. In addition, carryover less than 2.0 MAF provides little drought protection if the following year continues to be dry. As a result, years which fall into bin 3B are intended to be an "all-hands-on-deck" year where all actions from the drought tool kit are considered to determine if they can help support increased Shasta storage. In addition, these years are likely to be ones where the entire system is stressed and many actions from the Drought

Toolkit may be required to address the status of the entire system. It is likely that many drought actions considered in these years are not solely targeting Shasta storage but looking at system wide storage for meeting highest priority demands and providing some overall system wide drought protection should the following year be dry. There is confidence that a temperature management plan will include a strategy to provide winter-run Chinook spawning temperatures that avoid critical losses of egg and fry production, maintain key spawning refuges in upstream areas and avoid catastrophic impacts to the broodyear.

In these years, the primary management goals are to conserve storage and operate the TCD to target 53.5° F upstream of CCR for the most critical period during the winter-run spawning and egg incubation period to avoid critical loss of winter-run population. Reclamation will reduce Shasta releases for water supply (CVP allocations) to only that needed for meeting public health and safety demands, including minimum salinity levels in the Delta. Reclamation, through coordination with the SHOT, will identify moderate and heavy system-wide tradeoffs with the goal of conserving storage and meeting minimal temperature objectives. Moderate system wide tradeoffs generally include, but are not limited to, rebalancing between other CVP reservoirs with moderate impacts to other parts of the system, transfer timing modifications, situation-specific adjustments to Delta water quality standards under D-1641 to address developing drought conditions and other actions from the Drought Toolkit. Heavy system wide actions include requesting significant relaxations to D1641, limitations in water available under contract (see further description below) and other actions from the Drought Toolkit. In extremely dry years or in multi-year droughts, it is possible that these actions will not achieve an EOS storage above 2.0 MAF.

During Bin 3B years, defined as having an end of April storage below 3.0 MAF and a projected end of September storage less than 2.0 MAF, which are also designated as critical years under the SRSC's contracts and have an October through April inflow of less than 2.5 MAF, available water supply for diversion under the SRSCs is limited to between 75% and 50% of total contract quantities, or approximately 1.5 - 1.1 MAF. The available water for diversion within this range depends on the water available to meet an expected end of September storage of 2.0 MAF using a conservative forecast (90% exceedance or equivalent). This reduced volume of available water will be applied to all SRSCs collectively and individual contractor reductions may vary based on agreements and transfers between different SRSCs. In these years, previously described SRSC voluntary actions under their resolution may not be possible due to the very limited supply. It is also unlikely that VA water would be made available in these years as they are typically critical water year types. Should there be a request for a VA asset, the origin and use of that asset will be discussed through the appropriate governance teams. During these years, Reclamation will coordinate with FWS to maintain summer deliveries of Level 2 supplies to Sacramento Valley CVPIA refuges to provide essential dry year habitat for Giant Garter Snake, Western Pond Turtle, Tricolored blackbirds and migratory waterfowl in a manner consistent with refuge contracts and agreed upon operational priorities. If conditions remain dry through the fall Reclamation and FWS will coordinate on how to address instream flow objectives, lake levels and refuge needs. Reclamation

will continue to utilize level 4 to supplement supplies for refuges in drier years when storage and coldwater pool are limited.

SRSCs will be asked to provide input through the SHOT on minimum Keswick and Wilkins Slough flows to meet obligations to senior water right holders under the Sacramento River Settlement Contracts while meeting biological objectives and other requirements such as public health and safety. In situations where appropriate fall and winter flows were discussed and tradeoffs were evaluated but there was not agreement on the implemented flow regime from the SRSCs, SRSCs propose alternative methods to meet obligations to senior water right holders under the Sacramento River Settlement Contracts with the SHOT should the following year be a 3B year. Should a similar disagreement occur during a Bin 3B year after the Bin has been designated, flows in disagreement will not affect the determination on volume of available water. Under these conditions, the likelihood of storage below 2.0 MAF will increase. Reclamation will coordinate through the SHOT with a goal of agreement on all release decisions in 3B years in order to avoid a disagreement on the use of critical and limited water supplies.

- **Operational Goals and Objectives**
    - Maintain and conserve minimal storage for to avoid catastrophic low storages should the next year also be dry
    - Meet public health and safety demands including delta salinity
    - Meet obligations to senior water right holders under the Sacramento River Settlement Contracts
- **Biological Objectives**
    - Victorian objective: Protect
    - Avoid critical loss of population
    - Maintain key refuges of spawning and early rearing habitat
    - Avoid catastrophic changes to habitat and impacts to the broodyear
    - Manage winter-run spawning habitat upstream of CCR average daily water temperature of 53.5° F during the critical periods of the spawning and egg incubation period
    - Targeted Resulting Temperature Dependent Mortality to be ≤30%
    - Manage adult holding temperatures below 58 daily average to minimize pre-spawning mortality
    - Appropriate reach-specific survival objectives will be developed through the Winter-Run Action Plan
- **Bin 3A Operational Goals and Indicators**

- February or March forecasts project <3.0 MAF end of April storage based on 90% exceedance or other conservative approach
- February or March forecasts project >2.0 MAF end of September storage based on 90% exceedance or other conservative approach
- The goal of actions is to increase projected EOS storage to 2.2 MAF. If this is not possible to increase projected EOS storage above 2.0 MAF shift to Bin 3B

- **Bin 3B Operational Goals and Indicators**
  - Hydrologic Goal: Increase drought protection.
  - February forecasts projects <3.0 MAF end of April storage based on 90% exceedance or other conservative approach.
  - February forecasts projects <2.0 MAF end of September storage based on 90% exceedance or other conservative approach.
  - The goal of actions is to increase projected EOS storage above 2.0 MAF. If this is not possible identify system priorities and contingencies.

3.3 Egg Incubation and Emergence Temperature Objectives

Water temperature management generally occurs from May 15 through October 30th; however, start and end dates may be adjusted through coordination with the SRG and SHOT based on the winter-run Chinook salmon spawning and emergence. Water temperature management would target 53.5°F at locations identified in the Bins above. The application of Victorian Objectives will be applied to support a greater habitat extent, duration and frequency on the Sacramento River below Keswick Dam, when storage resources allow, water temperature management will expand habitat for early or later spawners, spawners further downstream, and juveniles rearing.

3.3.1 Temperature Management Plan

Reclamation will coordinate through the SRG to prepare a draft Temperature Management Plan (TMP) in April. The draft TMP will include: projected reservoir releases, assumed meteorological conditions, anticipated water temperatures and target locations, and temperature-dependent mortality (TDM) estimates for both Martin (2017) and Anderson (2022). Reclamation will finalize the TMP in May or later through coordination with the SRG and SHOT. Reclamation may update the TMP through coordination with the SRG and SHOT.

A final TMP after May is more likely in wetter years when the location of 53.5° F is expected to be downstream of CCR or in years when hydrologic conditions changed significantly after the draft TMP. For the final TMP, Reclamation will use conservative assumptions for determining the temperature management strategy, including relying on the actual May 1 storage, a conservative inflow forecast for inflow May through September, expected releases based on a conservative forecast and a conservative historical meteorology. Reclamation will utilize a forecast with 90% exceedance in the aggregate (when jointly considering multiple significant known uncertainties such as hydrology and meteorology) to develop conservative water

temperature forecasts, although certain circumstances may lead Reclamation to use different exceedance levels to incorporate an appropriately more conservative approach.

Reclamation will operate the Shasta Dam Temperature Control Device to manage water temperatures below Keswick Dam according to the Temperature Management Plan and monitor the results. Reclamation will proactively monitor and manage water temperatures and make operational changes to maintain temperatures consistent with the objectives from the TMP throughout the temperature management season. If monitored water temperatures exceed the average daily target temperature for three consecutive days, despite efforts to monitor conditions and manage proactively, Reclamation will notify NMFS of what actions, if any, are being or will be taken to address the exceedances and will arrange for a follow-up on day 4 if the actions do not resolve the issue. Reclamation will monitor implementation of the TMP using updated data on reservoir storage and coldwater pool via reservoir profiles and water temperatures downstream of Keswick Reservoir.

3.3.2 Temperature Profile Tracking

Reclamation will collect temperature profile measurements for Shasta (Table 3-2), Whiskeytown, and Trinity reservoirs every month at 25 ft intervals and distributed through the SRG following QA/QC.

Table 3-2. Temperature Profile Measurements for Shasta Reservoir

Dates	Profiles
Dec. – Feb.	Monthly at 25 ft. Intervals
Mar. – April	Every Two Weeks at 5 ft. Intervals
May – Nov. 15	Every Week at 5 ft. Intervals
Nov. 15 – Nov. 30	Every Two Weeks at 5 ft. Intervals

3.3.3 Annual Winter-run Chinook Salmon Broodyear Assessment

In order to inform operations, risk tradeoffs for determining the downstream extent of water temperature management, and the need to pursue increasing production or taking other actions at LSNFH, the JPE SubTeam will conduct a winter-run Chinook salmon broodyear assessment for the previous year's cohort and the cohort of return adults that hatched three years prior. The purpose is to track species conditions and take appropriate actions to avoid adverse impacts to the following year’s cohort. If the previous year’s cohort and the cohort three years prior, is determined to have experienced “adverse conditions”, then more actions would be taken to manage the objectives for each Bin, including both biological and drought protection objectives. The broodyear assessment will be developed by February 1 or each year using the best available science to guide calculation of each metric described below. The broodyear assessment will be based on the best available science each year and the JPE SubTeam may consider using the following indicators or information:

- >30% TDM
- <20% ETF survival

- 25% of historic JPE
- TMP compliance point was above CCR
- Adverse Population Viability Trends (per previous year's annual brood year report if there was an increase in any of the five criteria in Lindley et. al. 2007)
- High Risk of Extinction (per 5 year status review)
- Outyear adult escapement forecast based on Pacific Fishery Management Council winter-run stock abundance analyses

The JPE SubTeam will provide the broodyear assessment to Reclamation and the SHOT. If the broodyear assessment determines Adverse Conditions for Winter-run Chinook salmon and identifies that Shasta storage and hydrology are expected to result in continuing adverse conditions to the coming broodyear, the SHOT will report these conditions and proposed actions to the Directors and all reasonable actions will be taken to avoid continued adverse conditions. These indicators of broodyear strength can be revised by the SHOT with NMFS approval.

3.4 Sacramento River Settlement Contractor Resolution

The Sacramento River Settlement Contractors approved *A Resolution Regarding Salmon Recovery Projects in the Sacramento River Watershed, Actions Related to Shasta Reservoir Annual Operations, and Engagement in the Ongoing Collaborative Sacramento River Science Partnership Effort*. Pursuant to the resolution, the Sacramento River Settlement (SRS) Contractors will continue to participate in, and act as project champions for future Sacramento Valley Salmon Recovery Program projects, subject to the availability of funding, regulatory approvals, acceptable regulatory assurances, and full performance of the SRS Contracts.

Pursuant to the resolution, the SRS Contractors will meet and confer with Reclamation, NMFS, and other agencies as appropriate to determine if there is any role for the SRS Contractors in connection with Reclamation's operational decision making for Shasta Reservoir annual operations in those years. This determination will include consideration of what actions are feasible, consistent with the terms of the SRS Contracts. In addition to the 25% reduction during Shasta Critical Years as set forth in the SRS Contracts, the types of actions that may be considered include, but are not necessarily limited to: (1) the scheduling of spring diversions by the SRS Contractors; (2) voluntary, compensated water transfers by the SRS Contractors subject to Reclamation approval; and (3) smoothed SRS Contractor diversion for rice straw decomposition during the fall months. Any mutually agreeable proposed actions resulting from these meet-and-confer discussions must be consistent with the terms of the SRS Contracts and may also be subject to other regulatory approvals.

Decisions related to implementation of these Shasta-related voluntary actions will be carried out through SHOT.

3.4.1 Monthly SHOT Planning and Actions

This section describes the monthly SHOT planning process and actions that will be discussed. The planning approach is based on the seasonal water year and identifies actions that are necessary to implement the Shasta Management Plan.

- **October**
    - The SHOT begins meeting for the new water year.
    - Kick-off JPE SubTeam – establish 5-agency team, confirm meetings, schedule, work products.
    - Expected work products: JPE, Winter-run Broodyear assessment.
    - Begin tracking system conditions and hydrologic outlook. The goal is to take stock of system conditions and tracking water year hydrology.
    - SHOT discussing October releases for purpose of tracking Winter run redd dewatering and incidental take limits.
    - SHOT available for elevation for Redd Maintenance and Fall Flow Smoothing actions.
    - Reclamation, through coordination with SHOT, planning for winter refill flows.
    - Reclamation, through coordination with SHOT, tracking VA assets and discussing options for deployment.
    - If necessary, SHOT discussing water transfer schedules.
    - SHOT tracking downstream winter-run counts.
- **November**
    - SHOT provides support to JPE SubTeam as needed.
    - Continue tracking system conditions and hydrologic outlook.
    - SHOT discusses November–April Keswick minimum releases based on EOS. In the event of a dry fall where the previous year was a Bin 2 or 3 year, strive to get to 3,250 cfs by December 1 or sooner.
    - SHOT available to the SRG for elevation for Redd maintenance and Fall Flow Smoothing.
    - SHOT tracking winter refill flows.
    - SHOT is tracking VA assets and discussing options for deployment.
    - Receive winter-run adult spawning escapement numbers from summer.
    - SHOT tracking downstream winter-run counts.

- **December**
    - SHOT provides support to JPE SubTeam.
    - JPE SubTeam issues JPE Memo to SHOT by December 31.
    - Continue tracking system conditions and hydrologic outlook.
    - For the most part, December is not a drought planning month, but may be in extreme low storage conditions.
    - Under very dry fall conditions that have resulted in extremely low storage conditions, Reclamation and DWR, in coordination with the SHOT, will start to review the Drought Toolkit in anticipation of drought conditions developing or persisting.
    - Tracking fishery conditions.
    - SHOT is tracking VA assets and discussing options for deployment.
    - Review the temperature and TDM results from the previous water year versus the objectives from TMP to determine if 1) any deviances from the TMP were understood by the SRG and SHOT team, 2) if an independent panel review is appropriate for better understanding the differences and 3) if any adjustments to the planning process are warranted. In some cases, the SHOT may work with the SRG to conduct an operational and/or biological necropsy to determine the cause of any exceedance.
- **January**
    - SHOT provides support to JPE SubTeam
    - If an adjustment is needed, the JPE SubTeam will issue JPE Adjustment Memo to SHOT Team by January 15-31
    - SHOT reviewing drought tool kit in low storage years or if drought conditions are present
    - SHOT is tracking VA assets and discussing options for deployment
    - SHOT evaluating possible need for LSNFH production adjustments or other actions to protect winter-run production at the hatchery
    - SHOT considering non-critical year voluntary actions if low storage conditions or drought conditions are developing
- **February**
    - If February 90% forecast EOA/EOS projections indicate Bin 2:
        - SHOT may initiate Meet and Confer regarding water supply neutral actions. Discussions based on 90% February forecast unless a different forecast is more appropriate to reflect a conservative outlook.

- SHOT evaluating system-wide tradeoffs.
- SHOT evaluating Drought Toolkit for possible actions.
- FWS, through coordination with SHOT, determines if it's appropriate to increase production at LSNFH or to take other actions to protect winter-run production.
- Broodstock collection begin.
- VA asset planning begins.

- If February 90% forecast EOA/EOS projections indicate potential Bin 3:
  - SHOT may initiate Meet and Confer regarding voluntary actions discussions based on 90% February forecast unless a different forecast is more appropriate to reflect a conservative outlook
  - SHOT evaluating system-wide tradeoffs
  - SHOT evaluating Drought Toolkit for possible actions
  - FWS, through coordination with SHOT, determines if it's appropriate to increase production at LSNFH or to take other actions to protect winter-run production
  - Broodstock collection begin
- Regardless of Bin type:
  - JPE SubTeam issues annual winter-run broodyear assessment memo to SHOT.
  - SHOT coordination on February Operational Outlook.
  - Reclamation announces initial Shasta-critical determination and CVP allocations – Note: most deliveries do not start until April or May.
  - If Shasta end of September storage is projected to be above 2.4 MAF, then walk through the forecast after the allocation comes out.
  - If a borderline year, then Reclamation will discuss any key forecasting assumptions with the SHOT prior to allocations. This may include expected release ranges and storages for all reservoirs, expected pumping levels and expected regulatory requirements. Due to the very tight time frame for reviewing any data before the allocation is released, this may not include a full outlook but rather the key factors that prevent Shasta from reaching 2.4 MAF or higher. This may be done either verbally in a SHOT meeting or via email.
  - SHOT is tracking VA assets and discussing options for deployment
  - VA asset planning begins.

- SHOT begins discussing system-wide tradeoff actions.
- SRG meets to start planning for possible March pulse flow either from the Proposed Action or from the VAs. If SRG recommends an early (March) pulse flow, it will be recommended to SHOT as soon as possible but no later than the end of February.
- SHOT decision on spring pulse flow could be based on temp modeling or could be based on storage and broodstock only. If the SRG decides spring pulse flow is appropriate, will pass to SHOT as a recommendation. To the extent possible when consistent with action objectives, try to combine the spring pulse flow with meeting delta objectives, either D1641 or the VA system-wide objectives depending on the source of the pulse flow water.
- SHOT considers tradeoffs associated with a pulse flow action in the context of the broodyear assessment, projected EOA and EOS storage, system conditions, current hydrology and forecasts.

- **March**
  - If March 90% forecast indicates EOA/EOS projections indicate Bin 2:
    - SHOT needs confirmation on scheduling for spring diversions per SRSC resolution
    - Confirmation on resolution items, particularly the delayed spring offset and begin to get an idea of volumes of transfers
    - Preliminary temperature modeling; convene SRG
  - If March 90% forecast EOA/EOS projections indicate Bin 3:
    - Preliminary signal for allocation or delivery adjustments
    - Preliminary temperature modeling; convene SRG
  - Regardless of Bin type:
    - SHOT begins meeting weekly or as needed.
    - SHOT begins enhanced reporting out to Water Operations Management Team (WOMT).
    - SHOT initiates preliminary scenarios and TMP planning.
    - SHOT begins discussions to plan for April and May release patterns.
    - Continue to coordinate on non-critical year voluntary actions. Need a preliminary idea of SRSC diversion quantities and transfers.
    - SHOT evaluating Drought Toolkit for possible actions.
    - SHOT discusses potential signals for possible drought actions.

- Continuing to evaluate system wide tradeoffs.
- LSNFH broodstock collection continues.
- Reclamation shares the March Operational Outlook with the SHOT and any concerns or trade-offs are discussed as appropriate.
- Reclamation tracking Shasta Critical Determination.
- Reclamation announces March allocations if appropriate. SHOT coordination involves:
- If Shasta EOS is projected to be above 2.4 EOS, then walk through the forecast after the allocation comes out.
- If a borderline year, discuss key forecasting parameters that prevent Shasta from reaching 2.4 MAF.
- VA asset planning continues.
- SHOT discussing system-wide tradeoff actions.
- SRG Planning.
- SRG pulse flow group planning for possible March or April pulse flow.
- SHOT Decision on spring pulse flow – could be based on preliminary temp modeling or could be based on storage and broodstock only. If the SRG decides spring pulse flow is appropriate, will pass to SHOT as a recommendation. To the extent possible when consistent with action objectives, try to combine the spring pulse flow with meeting delta objectives either D1641 or the VA system-wide objectives depending on the source of the pulse flow water.
- SHOT considers pulse flow action in consideration of broodyear assessment, storage, system conditions…risk/balance/tradeoffs.

- **April**
  - If April 90% forecast indicates EOA/EOS projections indicate Bin 2:
    - Transfer planning – Identify bounds of volume and timing
  - If April 90% forecast EOA/EOS projections indicate Bin 3:
    - Transfer planning – Identify bounds of volume and timing
    - Final decisions on many drought actions including available water supply for SRSC diversions and diversion patterns
  - Regardless of Bin type:
    - SHOT meeting weekly or as needed

- SHOT continues enhanced reporting out to WOMT
- Reclamation announces April allocations if appropriate. SHOT coordination involves:
    - If Shasta EOS is projected to be above 2.4, then walk through the forecast after the allocation comes out
    - If a borderline year, then discuss key forecasting parameters that prevent Shasta from reaching 2.4 MAF
- SHOT continues planning discussions for April and May release patterns
- Continue to coordinate on non-critical year voluntary actions
- May pulse flow decision
- LSNFH actions continuing
- Reclamation shares the April Operational Outlook with the SHOT and any concerns or trade-offs are discussed as appropriate
- Draft Temperature Management Plan (table and/or graphs only – no report):
    - If going into a bin 2 or 3 (90% exceedance unless altered by hydrology) then based on March forecast with a date of April 15th to allow for SRG coordination
    - If bin 1, then date of April 30th using the April forecast unless later decided by SHOT
- Profile frequency – SHOT determines optimal frequency
- Determine final shoulder temps if necessary

- **May**
    - If May 90% forecast indicates EOA/EOS projections indicate Bin 2:
        - Transfer planning – Identify bounds of volume and timing
    - If May 90% forecast EOA/EOS projections indicate Bin 3:
        - Continue Meet and Confer. Make decisions regarding commitments under SRSC resolution
        - Transfer modifications – Draft/Final bounds
        - Evaluating Drought Toolkit if necessary
    - Regardless of Bin type:
        - SHOT back to meeting Monthly or as needed.

- Reclamation shares the May Operational Outlook with the SHOT and any concerns or trade-offs are discussed as appropriate.
- SHOT continues planning discussions for May release patterns.
- Final allocations in appropriate: SHOT Coordination includes:
    - If Shasta EOS is projected to be above 2.4, then walk through the forecast after the allocation comes out.
    - If a borderline year, then discuss key forecasting parameters that prevent Shasta from reaching 2,4 MAF.
- It is common that May will be the final allocation.
- Continue to coordinate on non-critical year voluntary actions.
- Evaluate system wide trade offs.
- LSNFH actions continue.
- Possible May pulse flow.
- Final TMP shared with both NMFS and the State Water Board with a copy to all SHOT and SRG members. Final will be issued by May 31st unless a later date is agreed upon by the SHOT.

- **June**
    - SHOT is meeting monthly or as needed and coordinating with the SRG during implementation of the TMP
    - SHOT may consider adjustments to the TMP if recommended by the SRG
- **July**
    - SHOT is meeting monthly, or as needed, and coordinating with the SRG during implementation of the TMP
    - SHOT may consider adjustments to the TMP
- **August**
    - SHOT is meeting monthly, or as needed, and coordinating with the SRG during implementation of the TMP
    - SHOT may consider adjustments to the TMP
    - SRG begins discussing fall release planning
- **September**
    - SHOT is meeting monthly, or as needed, and coordinating with the SRG during implementation of the TMP. There may be a need to coordinate fall transition

planning to minimize redd dewatering based on available cold water and overall storage conditions.

3.4.2 Drought Operations Priority Framework

Under certain conditions, such as prolonged drought or unexpected hydrologic conditions, the February 90% forecast may indicate that EOS is projected to be less than 2.0 MAF. Under these conditions, Reclamation will develop a drought emergency plan that, at a minimum, will include the following actions with the goal of achieving a projected EOS storage as close to 2.0 MAF as possible:

- Evaluation of system priorities.
- Plan to continue to pursue all applicable 3B actions.
- Full assessment of hydrologic and ecosystem conditions.
- Assessment of Public Health and Safety needs.
- Managing salinity to meet basic public health and safety needs.
- Ability to meet demands for public health and safety water deliveries.
- Enhanced coordination between the SHOT, Directors and SRSCs.
- After exploring all applicable 3B actions, develop a Temperature Management Plan which accounts for the drought emergency plan and applies the best available approaches for managing the available coldwater supply to best balance tradeoffs between the spatial and temporal extent of winter-run suitable habitat while considering impacts to other species.

All actions in the Drought Toolkit will also be considered. Over the long-term additional actions are being considered or implemented to provide improved conditions for species during future droughts in addition to the actions identified in this plan:

- Designing habitat projects with drought refugia and resilience in mind
- Investments in other habitats for salmon spawning
- Consider objectives when planning for and implementing other water projects

Management Rationale: In these circumstances, all of the relevant Bin 3B actions will be considered but there is a low likelihood that taking all of the actions would increase forecasted EOS conditions above 2.0 MAF and therefore, Reclamation, in coordination with the SHOT and WOMT, will develop a drought emergency plan that establishes system priorities and a temperature management plan that seeks to provide winter-run Chinook spawning temperatures to avoid catastrophic losses related to summer temperature management.

3.5 Clear Creek

As a component of the Trinity Division of the CVP, Reclamation operates and maintains Whiskeytown Dam on Clear Creek (Figure 3-3), with a capacity of 241,100 acre-feet, for irrigation and other beneficial uses, hydroelectric power generation, fish and wildlife, recreation, and upper Sacramento River temperature control and water rights requirements. Whiskeytown Lake provides reregulation of trans-basin imports from the Trinity River. Diversions from Lewiston Lake on the Trinity River through the Judge Francis Carr Powerhouse and the runoff from the Clear Creek drainage area flow into Whiskeytown Lake. Water from Whiskeytown Lake is released into Clear Creek, diverted through the Muletown Conduit, or diverted through the Spring Creek Tunnel and Spring Creek Powerplant into Keswick Reservoir. Whiskeytown Lake has two temperature curtains to pass cold water through the bottom layer and limit warming from Judge Francis Carr Powerhouse to the Spring Creek Powerplant.

Reclamation operates and maintains Spring Creek Debris Dam on Spring Creek, with a capacity of 5,870 acre-feet, for hydroelectric power generation and upper Sacramento River temperature control and water rights requirements. Spring Creek Debris Dam controls debris and contaminated runoff resulting from old mine tailings on Spring Creek, which would otherwise enter the Spring Creek Powerplant tailrace. Water from Spring Creek Debris Dam and Spring Creek Powerplant discharges into Keswick Reservoir.

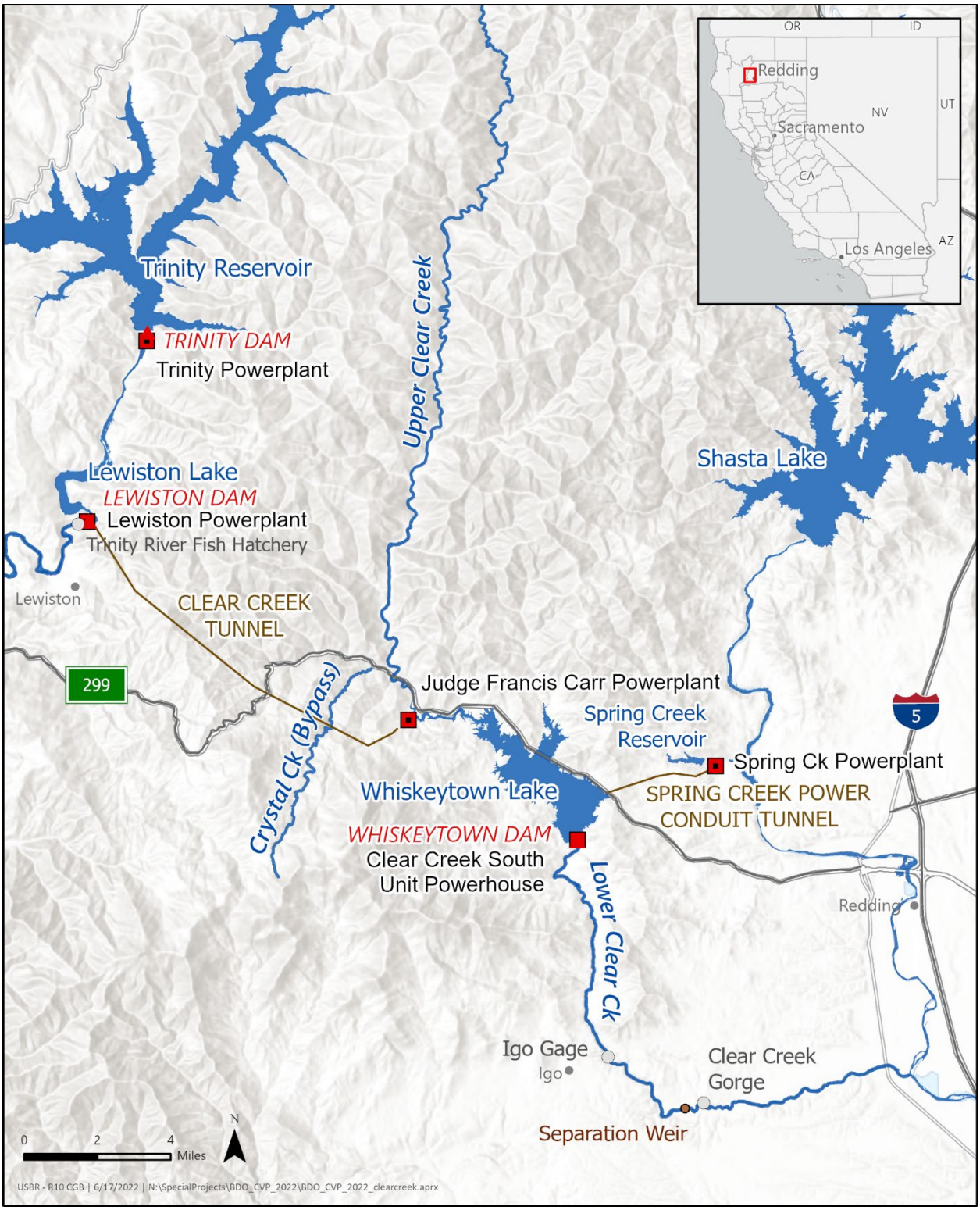


Figure 3-3. Clear Creek Facilities in the Trinity Division of the Central Valley Project

Statutory, Regulatory, and Contractual Requirements, see Appendix A:

- Public Law 84-386 Trinity River Division
- Section 3406(b)(12) of CVPIA
- Instream Flow Preservation Agreement 2000 (Contract No. 00-WC-1719-B8)
- April 15, 2002, State Water Board permit, minimum flows
- 1980 Memorandum of Understanding (MOU) with CDFW and the State Water Board (Spring Creek Debris Dam)

Programs in the environmental baseline to highlight:

- Spawning and Rearing Habitation Restoration

3.5.1 Seasonal Operations

In the winter and spring, Whiskeytown Lake is operated to regulate flows for flood management. Starting in November, Reclamation will draw down Whiskeytown Lake by approximately 35 TAF to create flood management space, generally refilling in April or May. USACE does not regulate Whiskeytown Lake for flood control. Operations at Whiskeytown Lake during flood conditions are complicated by its operational relationship with the Trinity River, Sacramento River, and upper Clear Creek. On occasion, imports of Trinity River water to Whiskeytown Lake may be suspended to avoid aggravating high flow conditions in the Sacramento Basin. Heavy rainfall events occasionally result in uncontrolled gloryhole spillway discharges to Clear Creek, through the Whiskeytown Gloryhole.

During the summer and early fall, Reclamation operates to provide lake elevations as full as practical for recreation. Whiskeytown Lake is a major recreational destination with recreational facilities administered by the National Park Service. Summer and fall imports help maintain Whiskeytown Lake elevations, provide cool water for releases to Clear Creek for temperature control objectives, decrease residence time in Lewiston Lake for Trinity River temperature control, and help maintain temperature objectives in the Sacramento River by supplying water to Keswick Reservoir.

3.5.2 Ramping Rates

Ramping rates address the stranding risk stressor. Reclamation will use down ramping rates of up to 25 cfs per hour and schedule these reductions in consideration of listed species behavior (e.g., diel movement patterns).

Reclamation may vary from these ramping requirements during flood control. Reclamation, through Clear Creek Technical Team (CCTT), may develop a faster or slower down ramping rate on a case-by-case basis.

3.5.3 Minimum Instream Flows (Seasonally Variable Hydrograph)

Minimum instream flows address habitat stressors. Reclamation will release water through Whiskeytown Dam to provide intra-annual variation to emulate natural processes. As provided in Figure 3-4 and Table 3-3, flows will oscillate over a 1-year period, with releases transitioning from 300 cfs in the winter, down to 100 cfs in the summer, and back to 300 cfs by the following winter. In critical years, Reclamation will target an average 150 cfs based on available water from Trinity Reservoir and attempt to maintain above 100 cfs.

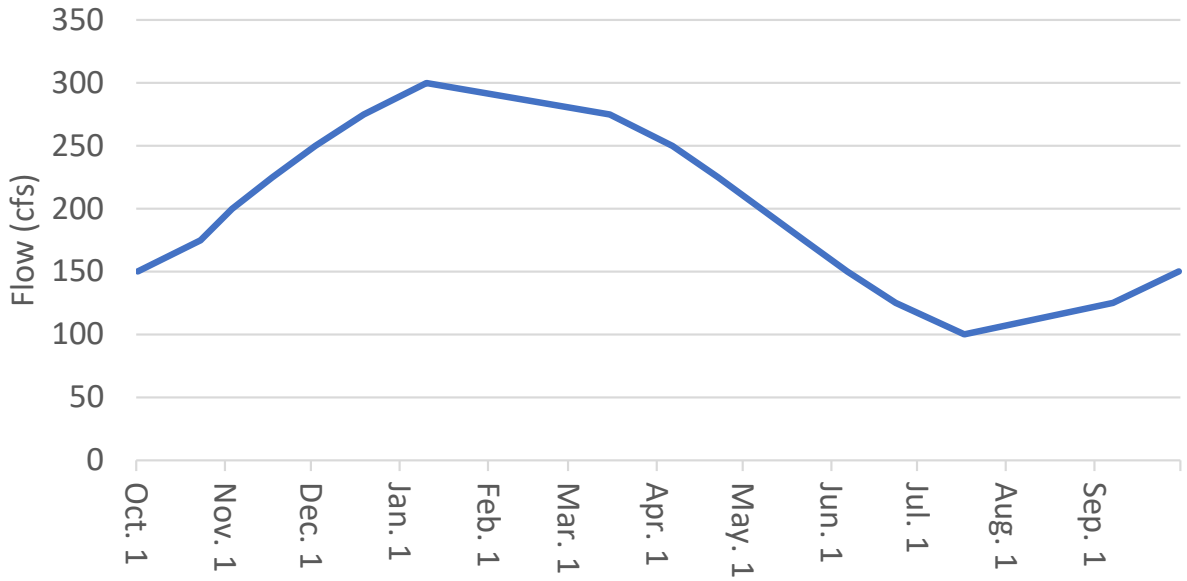


Figure 3-4. Clear Creek Seasonally Variable Hydrograph Minimum Flows, Except Critical Years

Table 3-3. Proposed Annual Clear Creek Flows Changes

Date	From (cfs)	To (cfs)
October 1	125	150
October 23	150	175
November 3	175	200
November 17	200	225
December 2	225	250
December 19	250	275
January 10	275	300
March 15	300	275
April 6	275	250
April 22	250	225
May 7	225	200

Date	From (cfs)	To (cfs)
May 22	200	175
June 6	175	150
June 23	150	125
July 17	125	100
September 7	100	125

cfs = cubic feet per second.

Reclamation, through the CCTT, will schedule the hydrograph to maximize multi-species benefits. Reclamation, through the CCTT, may modify the timing and flow rates provided in Figure 3-4 and Table 3-3 by February 1 and updated through May on a case-by-case basis. The flow schedule is subject to agreement by Redding Electric Utility for use of their facilities.

3.5.4 Pulse Flows

Pulse flows address the stressors on migration cues. Except in years with significant uncontrolled spill, Reclamation will release up to 10,000 acre-feet from Whiskeytown Dam for channel maintenance, spring attraction flows, and to meet other physical and biological objectives. In critical years, Reclamation will release up to 5,000 acre-feet. Reclamation, through CCTT, will develop pulse flow schedules, which include measures (e.g., nighttime down ramping, slow down ramping rates, coordination with natural precipitation events) to mitigate for potential risks (e.g., potential juvenile fish stranding). The pulse flows are not to exceed safe outlet works capacity of Whiskeytown Dam, currently 840 cfs, and will be scheduled on or after February 1.

Availability of water for pulse flows is tied to water year type. The determination of water year type will be based on the Sacramento Valley Index (SVI), at 90% exceedance level. Due to unknowns in winter precipitation, Clear Creek pulse flows are not to occur prior to the February SVI reporting. The full pulse flow volume (10,000 acre-feet) will be available if the SVI is greater than 5.4, at the SVI updates (i.e., dry or wetter years). If the SVI updates are equal to or less than 5.4 (critical years), Reclamation would limit releases of pulse(s) flows to 5,000 acre-feet.

3.5.5 Water Temperature Management

Water temperature management addresses adult water temperature and egg incubation stressors. Reclamation will target Whiskeytown Dam releases to not exceed the mean daily temperatures at Igo gauge:

- 61°F from June 1 through August 15
- 60°F from August 16 through September 15
- 56°F from September 16 through November 15

Water temperature management on Clear Creek is implemented through changes in guard gate configurations and flow manipulations. In dry, critical, or import curtailment years, Reclamation may not be able to meet these temperatures and will operate Whiskeytown Dam as close to these temperatures as practicable.

Additional flows may be required to meet temperature objectives. Reclamation will determine if additional water is available for temperature management and inform the agency representatives through the CCTT. If two consecutive days of mean daily temperature are exceeded, and Reclamation determines additional water is available, then 25 cfs per day will be added to the base flow to address temperatures.

Any flow changes completed for temperature management in the late-summer or fall, implemented at 25-cfs increments, would be maintained until the base flow of the seasonal hydrograph rises to meet the elevated temperature release. For example, if flows were increased to 150 cfs on September 10 to decrease water temperatures, they would remain there until October 23 when the hydrograph would normally increase to 175 cfs. This relieves the need to down ramp during spawning and potentially dewater redds. If additional flows are needed to meet temperature in late spring or summer during a hot spell for instance, ramp-down to base flow would occur when meteorological conditions allow.

3.5.6 Segregation Weir

The segregation weir addresses competition, introgression, and broodstock removal stressors. Reclamation proposes to ensure placement of a segregation weir on Clear Creek typically installed between the Clear Creek Gorge Cascade and Clear Creek Road Bridge in late August and remain in place through early November. Reclamation, through the CCTT, will select the location based on channel cross-section suitability for weir placement and the distribution of adult spring run Chinook Salmon holding locations. Previous placements have occurred at River Mile (RM) 8.2 or 7.5. An additional location is being prepared at RM 7.25. Placement of the weir would occur before fall run Chinook Salmon enter Clear Creek to minimize hybridization with spawning spring-run Chinook Salmon and redd superimposition. Removal of the weir would occur after the peak of fall run Chinook Salmon spawning when the risk of redd superimposition is very low. The weir location and timing protect most of the spring-run Chinook Salmon utilizing Clear Creek, while minimizing effects on other salmonids.

3.6 American River

Reclamation operates and maintains the American River Division of the CVP for flood control, M&I and agricultural water supplies, hydroelectric power generation, fish and wildlife protection, recreation, and Delta water quality. Facilities include Folsom Dam, its reservoir (977 TAF capacity), power plant, temperature control shutters on the power plant, and the Joint Federal Project auxiliary spillway, as well as the Nimbus Dam, Lake Natoma, Nimbus Power Plant, and Folsom South Canal (Figure 3-5). The CVP additionally delivers water to the Freeport Regional Water Project Intake. Releases from Folsom Dam are re-regulated approximately seven miles downstream by Nimbus Dam. Nimbus Dam creates Lake Natoma, which serves as a forebay for diversions to the Folsom South Canal and the Nimbus Fish Hatchery. Water diverted to the fish hatchery returns to the American River through four outfalls approximately 0.5 mile downstream of Nimbus Dam. Releases from Nimbus Dam to the American River pass through the Nimbus Power Plant, or the spillway gates at flows more than 5,000 cfs.

Folsom Reservoir is the main storage and flood control reservoir on the American River. Numerous other smaller non-CVP and SWP reservoirs in the upper basin provide hydroelectric generation and water supply without specific flood control responsibilities. The total upstream reservoir storage above Folsom Reservoir is approximately 820 TAF, and these reservoirs are operated primarily for hydropower production. Ninety percent of this upstream storage is contained by five reservoirs: French Meadows (136 TAF); Hell Hole (208 TAF); Loon Lake (76 TAF); Union Valley (271 TAF); and Ice House (46 TAF). Reclamation coordinates with the operators of these non-CVP and SWP reservoirs to aid in planning for Folsom Reservoir operations.

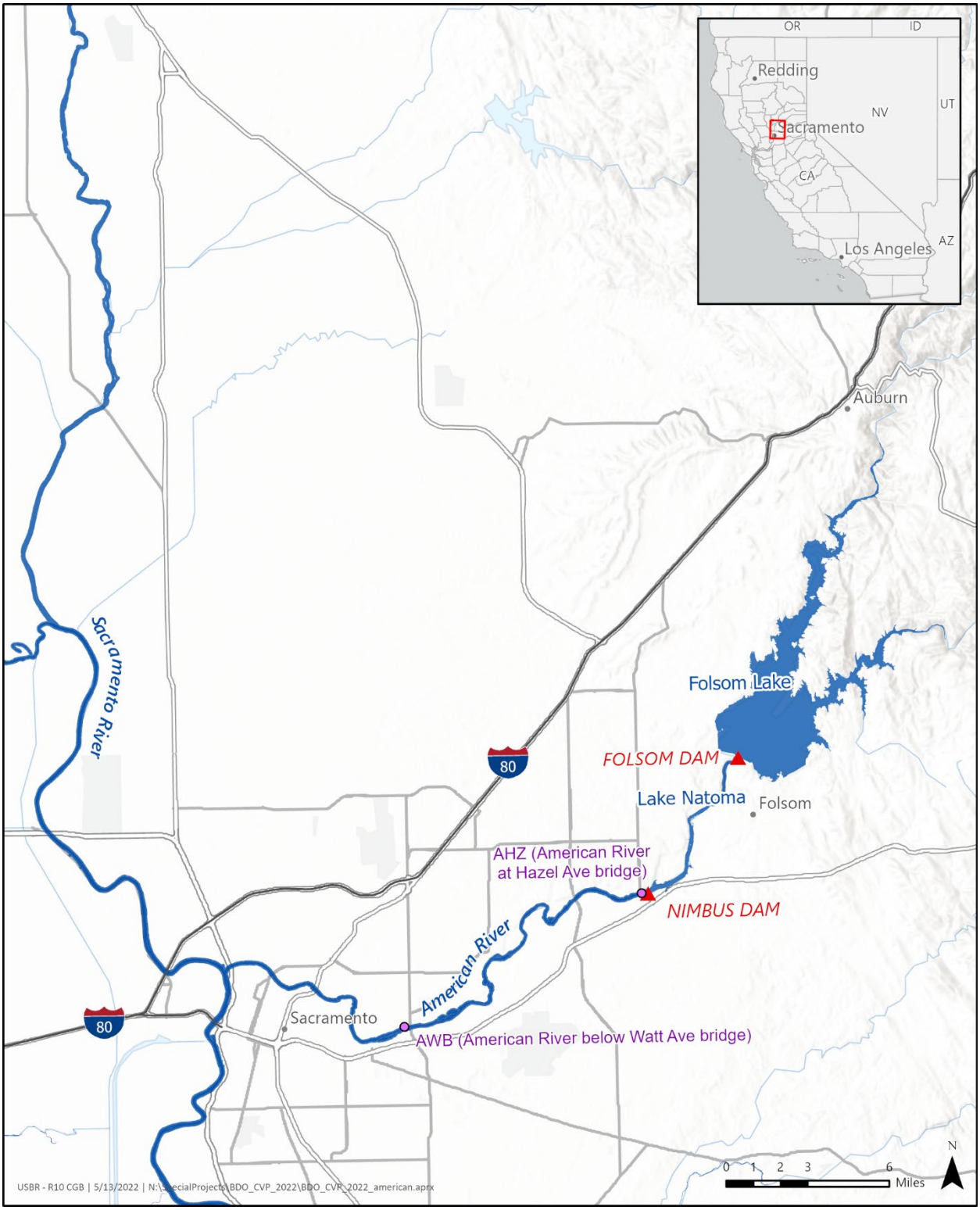


Figure 3-5. Facilities in the American River Division of the Central Valley Project

Statutory, Regulatory, and Contractual Requirements, see Appendix A:

- Public Law 81-356 American River Development Act of October 14, 1949, ch. 690, 63 Stat. 852
- Public Law 89-161 Auburn-Folsom South Unit - Act of September 2, 1965, 79 Stat. 615
- Freeport Regional Water Authority Intake
- State Water Board D-893
- State Water Board D-1641
- Water Control Manual for Folsom Dam and Lake (June 12, 2019) and its October 16, 2018, NMFS Biological Opinion
- Water Forum MOU March 29, 2021

Programs in the environmental baseline to highlight:

- Nimbus Hatchery Genetics Management Plan
- Temperature Modeling Platform.
- Spawning and Rearing Habitat Restoration.
- Folsom Dam Raise and Temperature Control Shutters

3.6.1 Seasonal Operations

Reclamation operates Folsom Reservoir in the winter primarily for flood control and minimum flows in the American River and Delta. Flood control may drive operations in wetter years. The USACE 2019 *Water Control Manual: Folsom Dam and Lake* provides operational rules for dam safety and flood risk management. Flood operation criteria target flow rates below downstream channel capacities. During non-flood control operations, Reclamation stores Folsom Reservoir inflows that exceed releases for minimum instream flows and Delta water quality requirements. Reclamation seeks consistent steady releases to minimize potential redd dewatering, redd scouring, and juvenile stranding for steelhead and fall-run Chinook salmon, but Delta outflow requirements may require varying releases.

In the spring, when not operating to flood control requirements, Reclamation seeks to maximize capture of the spring runoff to fill as close to full as possible. The American River Minimum Flow Schedule (ARMFS), Appendix ARMFS, includes both minimum releases and, in some years, a pulse flow to cue juvenile salmonids to emigrate. Reclamation also operates for water supply and Delta outflow requirements. As the closest reservoir to the Delta, increased releases from Folsom are frequently called on to address Delta water quality requirements under State Water Board D-1641. When releases from upstream CVP and SWP reservoirs meet Delta outflow requirements, Folsom releases can be reduced, and system-wide reservoirs balanced.

When developing the operational forecast, Reclamation would evaluate an end-of-December Folsom storage of at least 300 TAF. In some years, operational constraints may result in an end-of-December storage of less than 300 TAF. If, based on the May forecast, Reclamation does not anticipate meeting 300 TAF at the end of December, it will be reported at the May American River Group meeting. In those instances, Reclamation and the American River Parties will develop a list of potential actions that may be taken to either improve forecasted storage or decrease demand on Folsom Reservoir. The objective of considering storage in the forecasting process is to provide releases of salmonid-suitable temperatures to the Lower American River and reliable deliveries to American River water agencies dependent on deliveries or releases from Folsom Reservoir. In September, storage is typically at its lowest after releases and diversions for summer demands. When planning in the spring for temperature management later in the year, meteorological forecasts of precipitation events are uncertain for October through December. Assuming higher precipitation events than may materialize may present a higher risk of the reservoir not having sufficient carryover storage by the end of December. Reclamation is implementing a pilot program that considers an end-of-December planning minimum of 300 TAF (Water Forum MOU, March 2021).

In the summer, Reclamation typically releases flows above the minimum instream flow requirements for instream temperature control, Delta outflow, and water supply. Reclamation manages water temperatures through the volume of water released and shutter elevations, in consideration of projected meteorological conditions. Reclamation balances the need to access Folsom Reservoir coldwater pool for instream temperature control during the summer for steelhead and the need to preserve cold water for fall-run Chinook salmon.

In the fall, operations focus on temperature control management. Limited coldwater pool and limited storage require balancing releases and shutter operations to maximize the ability to maintain suitable temperatures for steelhead rearing and fall-run Chinook salmon spawning. If reservoir inflows are greater than the release needs, Reclamation stores the surplus water. Reclamation will ramp down to the revised minimum flows from Folsom Reservoir as soon as possible in the fall and maintain these flows through fall-run Chinook salmon spawning and egg emergence, where possible, to minimize redd dewatering and juvenile stranding.

3.6.2 Ramping Rates

Ramping rates address the stranding stressor. Reclamation will ramp down releases in the American River below Nimbus Dam as shown in Table 3-4 and at night, if possible.

Table 3-4. American River Ramping Rates

Lower American River Daily Rate of Change (cfs)	Amount of Decrease in 24 Hours (cfs)	Maximum Change per Step (cfs)
20,000 to 16,000	4,000	1,350
16,000 to 13,000	3,000	1,000
13,000 to 11,000	2,000	700
11,000 to 9,500	1,500	500
9,500 to 8,300	1,200	400

Lower American River Daily Rate of Change (cfs)	Amount of Decrease in 24 Hours (cfs)	Maximum Change per Step (cfs)
8,300 to 7,300	1,000	350
7,300 to 6,400	900	300
6,400 to 5,650	750	250
5,650 to 5,000	650	250
<5,000	500	100

cfs = cubic feet per second.

Reclamation may vary from these ramping requirements during flood control. Reclamation, through the American River Group (ARG), may develop a faster down ramping rate on a case-by-case basis to implement temporary flow reductions for critical monitoring or maintenance needs.

3.6.3 Minimum Instream Flows (Minimum Release Requirements)

Minimum release requirements address egg dewatering, adult stranding and juvenile habitat stressors. For lower American River flows (below Nimbus Dam), Reclamation proposes to adopt the ARMFS. The ARMFS is based on the Modified Flow Management Standard developed by the Water Forum in 2017 (2017 MFMS), with additional modifications as described below. The ARMFS includes minimum release requirements (MRRs) ranging from 500 to 2,000 cfs based on time of year and annual hydrology. The flow schedule is intended to provide suitable habitat conditions for steelhead and fall-run Chinook salmon. As detailed in Appendix S, the Sacramento River Index (90% exceedance forecast) will be used to develop the MRR in January. The American River Index (90% exceedance forecast, with certain spills subtracted) will be used to calculate the MRR in February through December. All MRR calculations will be based on the hydrologic indices reported in the first Bulletin 120 of each month. Reclamation will continue to work with the American River Group to coordinate the shaping of upcoming releases within operational constraints.

Key differences in the ARMFS compared to the 2017 MFMS include the following:

- While the 2017 MFMS calculates the MRR for each month using a hydrologic index based on a 50% or 75% exceedance forecast, Reclamation proposes to calculate the MRR based on the 90% exceedance forecast for the relevant hydrologic index.
- The 2017 MFMS didn't specify how to transition from one month's MRR to the next month's MRR. In the ARMFS, Reclamation established a more defined timeframe for when the MRR would go into effect, targeting five business days after the initial monthly release of Bulletin 120. If the MRR is not implemented within five business days, Reclamation will notify the American River Group.

- Within one year of the Record of Decision (ROD), Reclamation, through the American River Group, will (a) evaluate the equations used to calculate the MRRs in November through December to consider whether an adjustment to the maximum MRR is warranted based on habitat improvements and other relevant information, (b) develop recommendations, (c) and explanations on any recommendations not accepted.
- The offramp and volume offset in the spring pulse flow were removed so that in years when a spring pulse flow is triggered (based on the March MRR), the full volume is available to shape without a reduction in the MRR later in the spring. The current Proposed Action also specifies that the fish agencies, within operational constraints, may determine the timing of the flow.

3.6.4 Spring Pulse Flows

Spring pulse flow addresses stressors on outmigration cues to increase emigration rates and move juveniles downstream. Reclamation will implement a spring pulse in years that the MRR for March (based on the March forecast) is between 1,000 cfs and 1,500 cfs, as described in the ARMFS. The peak flow of the pulse flow would be 3 times the March MRR, even if implemented in April or May, but no higher than 4,000 cfs and lasting two days. Following two days at the peak flow, Nimbus releases would be decreased at no more than 500 cfs per day and no more than 100 cfs per hour. Changes in Nimbus releases would occur at night, if possible. The American River Group will provide technical input on shaping Spring Pulse Flow volumes, with the final timing determined by CDFW, FWS, and NMFS.

Reclamation, through the ARG, will develop a pulse flow schedule. Reclamation, through the ARG, may facilitate an additional spring pulse flow event if water is made available from non-CVP sources, or if there is flexibility to shape planned releases in a more variable schedule.

3.6.5 Redd Dewatering Protective Adjustments

The redd dewatering protective adjustment (RDPA), as described in ARMFS, adjusts the MRR to account for hydrology and potential dewatering impacts to fall-run Chinook salmon redds in January and February and steelhead redds in February through May based on the MRR. Dewatering Protective Adjustments based on the MRR are not protective when actual flows in-river are above the MRR. Releases can be above the MRR in the fall and winter due to contractual obligations, Delta water quality requirements, and precipitation events. There are not Redd Dewatering Protective Adjustments based on actual flows. The American River Group will provide technical input on shaping Redd Dewatering Projective Adjustments.

In January, the MRR can only decrease and cannot be less than 70% of the December MRR. In February, the MRR cannot be less than 70% of the December MRR. Based on the January MRR, Table 3-5 shows the minimum flow for steelhead redds through May. If the February MRR is higher than January, the February MRR is used through May.

Table 3-5. Steelhead Redd Dewatering Protective Adjustment-Based MRR for February through May[3]

January or February MRR (cfs)	Steelhead Redd MRR through May (cfs)
≤700	500
800	520
900	580
1,000	640
1,100	710
1,200	780
1,300	840
1,400	950
1,500	1,030
1,600	1,100
1,700	1,180
1,800	1,250

cfs= cubic feet per second; MMR = minimum release requirement.

The maximum MRR in January through May is 1,750 cfs, but 1,800 cfs is included in the table as a maximum value. In February, the ARI-based and fall-run Chinook salmon RDPA-based MRRs for February are compared to the steelhead RDPA-based MRR in Table 3-5, using the controlling MRR in January as a basis. The highest of the three MRRs controls operations.

For March through May, the ARI-based MRR for the month is compared to the steelhead RDPA-based MRR in Table 3-5, using the highest of the controlling MRRs in January or February as a basis. The highest of the two MRRs controls operations.

3.6.6 Water Temperature Management

Temperature management supports fall-run and addresses the water temperature stressor on steelhead. The most suitable water temperature for juvenile steelhead rearing habitat in the lower American River is 65°F or lower. Ideally, the Temperature Management Plan would provide for daily average water temperatures no higher than 65°F from Nimbus Dam (just upstream of the Hazel Avenue bridge) down to the Watt Avenue bridge. The active temperature management season is approximately May 15 to October 31. Of additional importance, water temperatures below 56°F are suitable for fall-run Chinook salmon spawning. Carcass surveys in the lower

[3] The maximum MRR in January through May is 1,750 cfs, but 1,800 cfs is included in the table as a maximum value

American River indicate spawning from approximately mid-October through December and into January.

Reclamation will implement the Automated Temperature Selection Procedure (ATSP), which was developed in consultation with representatives of state and federal agencies and prioritizes water temperatures during the summer to support steelhead rearing over water temperatures in the fall to support Chinook salmon spawning. Each ATSP schedule determines a monthly series of water temperature targets (for daily average water temperature) at the Watt Avenue bridge. Schedule 1 has a water temperature upper limit of 63°F from May through September, and 56°F in October and November. Schedule 78 has a water temperature upper limit of 72°F from May through November. Schedules 2 through 77 each represent a change in a single month's upper temperature limit by 1°F. Reclamation would consider modification to the ATSP or utilize another method in the event ARG members and fish agencies request consideration based on year-type conditions.

In years in the lower American River will have temperatures unsuitable for rearing or spawning, Reclamation, will meet with fisheries agencies to evaluate actions that can be taken to minimize temperature impacts to fisheries, may modify the ATSP as follows:

- For Schedule 28 or higher (greater than 65°F at Watt Avenue Bridge, May through September), the TMP may consider a temperature location at Hazel Avenue
- For greater than 65°F at Hazel Avenue bridge for May through September, the TMP will include an evaluation of whether modified Folsom operations could support an improved temperature schedule (e.g., an alternate release schedule over the summer)
- For greater than 68°F at Hazel Avenue for May through September, the TMP will include an evaluation of whether modified Folsom operations could support an improved temperature schedule (e.g., an alternate release schedule over the summer) and evaluate a power bypass during the summer and/or fall
- For greater than 56°F at Hazel Avenue in November, the TMP will evaluate a power bypass in the fall, with the evaluation likely to occur in August and September

By May 15, Reclamation will provide a draft TMP and solicit technical input from the ARG. By June 15, Reclamation, through ARG, will annually prepare a Temperature Management Plan for the summer through fall. The Temperature Management Plan will contain: (1) forecasts of hydrology and storage; and (2) a modeling run or runs, using these forecasts, demonstrating what temperature compliance schedule can be attained. Reclamation will plan shutter configurations to attain the best possible (lowest numbered) temperature schedule. The priority for use of the lowest water temperature control shutters at Folsom Dam, within operational constraints, will achieve the water temperature requirement for steelhead, and may also be used to provide cold water for fall-fun spawning. During plan implementation, if the temperature is exceeded for 3 consecutive days, or is exceeded by more than 3°F for a single day, Reclamation, will notify NMFS and the ARG, and outline steps to realign water temperature with the Temperature Management Plan.

3.7 Delta

Reclamation operates and maintains the Delta Division of the CVP for M&I and agricultural water supplies, hydroelectric power generation, fish and wildlife protection, recreation, and Delta water quality. The major CVP features are the Delta Cross Channel, Contra Costa Canal and Rock Slough Intake facilities, Tracy Fish Collection Facility and C. W. "Bill" Jones Pumping Plant (Jones Pumping Plant), and Delta-Mendota Canal (Figure 3-6). The Jones Pumping Plant, located about 5 miles north of Tracy, has six fixed-speed pumps with an operating capacity of 4,600 cfs. The Jones Pumping Plant discharges into the head of the Delta-Mendota Canal.

Reclamation operates and maintains the San Luis Unit of the West San Joaquin Division for M&I and agricultural water supplies, hydroelectric power generation, fish and wildlife protection, recreation, and water quality. The major joint CVP and SWP features are the O'Neill Forebay, San Luis Reservoir, Bernice Frederic Sisk Dam, O'Neill Pumping-Generating Plant, William R. Gianelli Pumping-Generating Plant, San Luis Canal, Dos Amigos Pumping Plant, and Los Banos and Little Panoche Detention Dams and Reservoirs. The major CVP-only facilities include the Coalinga Canal and Pleasant Valley Pumping Plant.

Reclamation operates the San Felipe Division for M&I and agricultural water supplies, fish and wildlife protection, and recreation. The major CVP features are the Pacheco Pumping Plant, Tunnel, and Conduit.

The main SWP Delta features are the Barker Slough Pumping Plant, Suisun Marsh facilities (including the Suisun Marsh Salinity Control Gate, Roaring River Distribution System, Morrow Island Distribution System, Goodyear Slough Outfall Gates), Clifton Court Forebay, and John E. Skinner Delta Fish Protective Facility (Skinner Fish Facility), Harvey O. Banks Pumping Plant (Banks Pumping Plant) and a portion of the California Aqueduct. The Barker Slough Pumping Plant diverts water from Barker Slough into the North Bay Aqueduct for delivery to the Solano County Water Agency and the Napa County Flood Control and Water Conservation District. The Suisun Marsh Salinity Control Gates (SMSCG) are located on Montezuma Slough about 2 miles downstream from the confluence of the Sacramento and San Joaquin Rivers, near Collinsville. The purpose of SMSCG operation is to decrease the salinity of the water in the eastern portion of the Suisun Marsh. When operated tidally, the gates reduce salinity by restricting the flow of higher salinity water from Grizzly Bay into Montezuma Slough during incoming tides and by retaining lower salinity Sacramento River water from the previous ebb tide. Operation of the gates in this fashion lowers salinity in eastern Suisun Marsh channels and results in a net movement of water from east to west through Suisun Marsh.

The SWP Banks Pumping Plant, located near the Jones Pumping Plant, has 11 pumps. Pumping is limited to a maximum permitted capacity of 10,300 cfs per day. The Banks Pumping Plant discharges into the California Aqueduct.

The Delta-Mendota Canal/California Aqueduct Intertie is used to move water between the California Aqueduct and the Delta-Mendota Canal and can pump up to 700 cfs from the Delta-Mendota Canal to the California Aqueduct and convey up to 900 cfs from the California Aqueduct to the Delta-Mendota Canal. This structure was built to help both federal and state water projects more effectively move water from the Delta into the San Luis Reservoir.

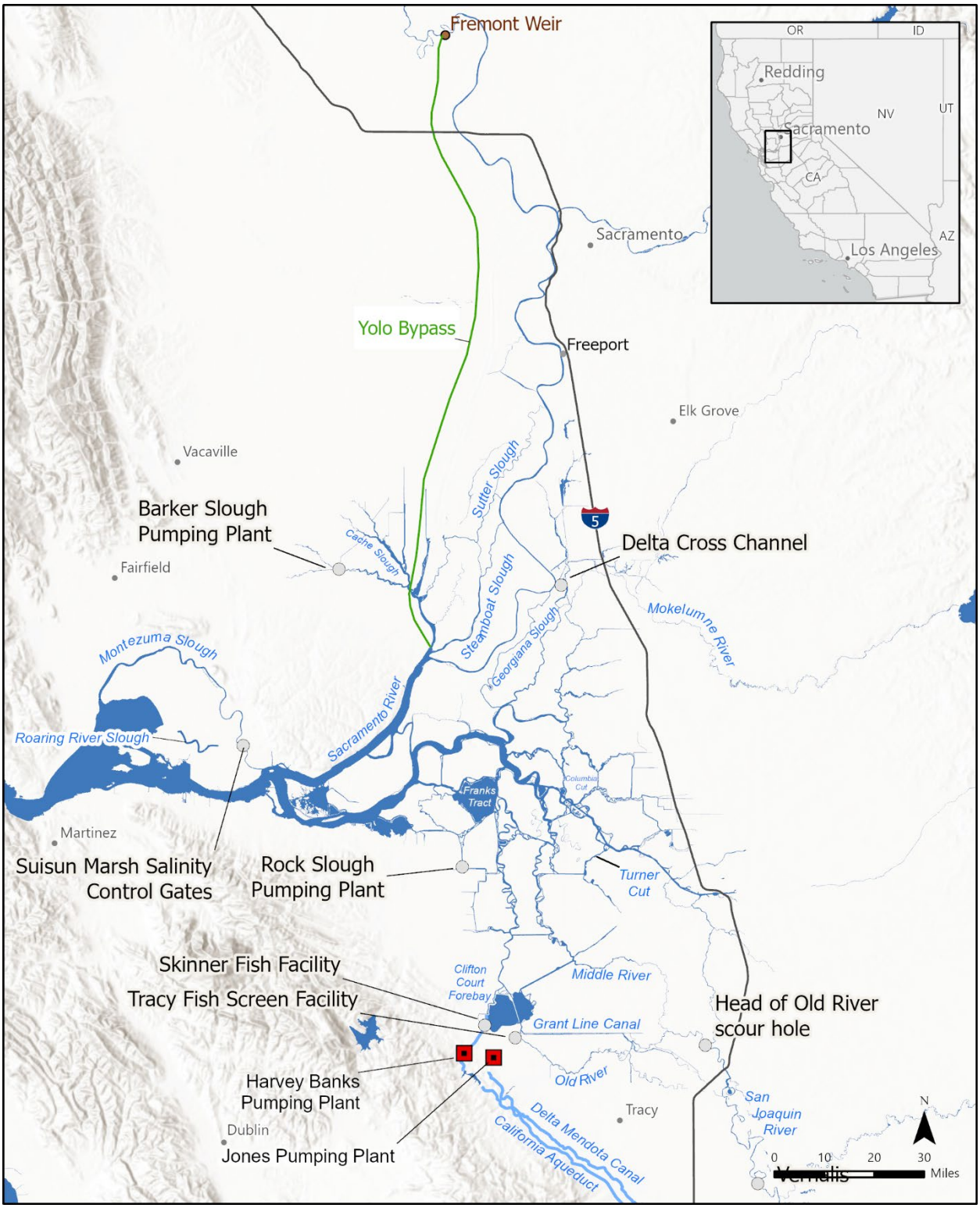


Figure 3-6. Map of the Delta Division Facilities

Statutory, Regulatory, and Contractual Requirements, see Appendix A:

- Public Law 74-392 CVP Re-Authorization Act
- State Water Board D-1641
- 1986 COA and 2018 COA amendment
- Public Law 99-546, Suisun Marsh Preservation Act
- 1986 Settlement Agreement with South Delta Water Agency (Clifton Court Forebay gate operations)
- October 13, 1981, USACE Public Notice #5820A (Clifton Court inflow criteria)
- DWR's Division of Safety of Dams criteria (Clifton Court Forebay storage)
- USACE permit number 199900715 (Clifton Court Forebay additional 500 cfs)
- DWR/CDFW Agreement (Skinner Fish Facility)
- USACE permit numbers SPK-200100121, SPK-20000696 (Temporary Barriers)

Programs in the environmental baseline to highlight:

- Agricultural Barrier Construction (USACE)
- Barker Slough Pumping Plant Fish Screen (DWR)
- Contra Costa Los Vaqueros Expansion – Phase 1
- Contra Costa Rock Slough Fish Screen
- Delta Cross Channel Gate Improvements Study
- Georgiana Slough Non-Physical Barrier (DWR, USACE)
- Head of Old River – Scour Hole Predation Reduction Study
- B.F. Sisk Dam Raise and Reservoir Expansion Project Construction
- Suisun Marsh Habitat Management, Preservation, and Restoration Plan
- Tracy Fish Collection Facility Improvement Program
- Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project

3.7.1 Seasonal Operations

In the winter and spring, Reclamation and DWR typically export excess water. Excess water conditions occur when releases from upstream reservoirs plus unregulated flow exceed Sacramento Valley in-basin uses and exports. Actions to minimize entrainment of listed fish into the south Delta and at the Jones and Banks Pumping Plants limit the export of excess water. Exports during the winter and spring reduce the reliance on conveying previously stored water in the summer and fall for south-of-Delta water supply needs. In dry conditions, Reclamation and DWR may need to increase releases from upstream reservoirs beyond what is needed to meet minimum flow requirements in order to meet water quality or outflow requirements in the Delta.

During the summer, the CVP and SWP convey previously stored water through the Delta for export at the Jones Pumping Plant, Banks Pumping Plant, and other Delta facilities. Delta operations during the summer typically focus on maintaining salinity and meeting Delta outflow objectives while maximizing exports with the available water supply. In addition, the CVP and SWP make upstream reservoir releases for water temperature management and instream flows, which may be available for export after outflow, salinity, and in-Delta needs have been met.

In the fall, operations are adjusted to meet salinity requirements, Delta outflow requirements, and peak demands from CVPIA wildlife refuges. Upstream and in-Delta demands typically decrease, and accretions within the system typically increase. When water is available and not required for salinity and Delta outflow requirements, late summer and fall provide an opportunity to export water and start filling San Luis Reservoir for the next water year. When conditions are dry, there is little opportunity for exports. Releases from upstream reservoirs generally decrease to conserve water in storage for the next year. On occasion, releases to conserve flood storage or redds may occur and result in additional flows into the Delta.

The Banks Pumping Plant pumps water from Clifton Court Forebay. The Clifton Court Forebay radial gates are closed during critical periods of the ebb and flood tidal cycle for water quality and water levels in the south Delta. During July through September, the maximum daily diversion limit from the Delta into the Clifton Court Forebay is increased from 6,990 cfs to 7,490 cfs, and the maximum averaged diversion limit over any 3 days is increased from 6,680 cfs to 7,180 cfs. From mid-December through mid-March, diversions into Clifton Court Forebay may be increased by one-third of the San Joaquin River flow at Vernalis when those flows exceed 1,000 cfs. Further, Banks Pumping Plant will pump up to 195,000 acre-feet for the CVP in accordance with the 2018 COA Addendum.

3.7.2 Delta Cross Channel Gate Closures

The Delta Cross Channel (DCC) closures address the outmigration cues and entrainment risk stressor for salmon and steelhead. Reclamation operates the Delta Cross Channel to: improve the movement of water from the Sacramento River to the export facilities at the Jones and Banks Pumping Plants; improve water quality in the central and south Delta; reduce salinity intrusion rates in the west Delta; and allow passage for boaters. Reclamation closes the Delta Cross Channel during the late fall, winter, and spring to reduce straying of Mokelumne River fall-run Chinook salmon, protect out-migrating salmonids from entering the interior Delta, facilitate the State Water Board D-1641 Rio Vista flow objectives for fish passage, and reduce potential scouring and flooding that might occur in the channels on the downstream side of the gates when Sacramento River flows exceed 20,000 cfs on a sustained basis. Delta Cross Channel closure will continue to occur as follows:

3.7.2.1 October 1 – November 30, Catch Index Closure

From October 1 through November 30, Reclamation proposes to close the DCC gates in addition to the requirements in D-1641 to further reduce juvenile salmonid entrainment risk based on the Knights Landing Catch Index and Sacramento Catch Index as described in Table 3-6. Observations of daily increases in catch indices are typically associated with increased flows at Wilkins Slough and tributaries to the upper Sacramento River, cooler water temperatures at these locations, and entry of migrating juvenile winter-run and spring-run Chinook salmon (Del Rosario et al. 2013; White and Low 2006).

Table 3-6. Delta Cross Channel Action Triggers and Responses from October 1–November 30

Action Trigger	Action Response
• Water quality criteria per D-1641 are met; and • Knights Landing Catch Index or Sacramento Catch Index (daily index) ≥ 3.0	Within 48 hours of index being reported to Reclamation, close the DCC gates for at least 3 days and keep closed until the catch index is less than three fish per day at both the Knights Landing and Sacramento monitoring sites for two consecutive days
• Water quality criteria per D-1641 are met; and • Knights Landing Catch Index or Sacramento Catch Index (daily index) ≥ 3.0; and • Real time hydrodynamic and salinity modeling shows water quality levels of concern criteria (as presented in Table 3-7) are exceeded during 14- day period following DCC closure	Reclamation and DWR, through Delta Monitoring Teams, review monitoring data and complete risk assessment to inform real-time operations of DCC gate closure.
• Water quality criteria are not met per D-1641 criteria	No DCC gate closure

Indices: Juvenile Chinook salmon at or above the minimum winter-run size based on the length-at-date Delta model used at a particular sampling location, and below the maximum size (for any run of salmon) considered by the length-at-date Delta model, on a given sampling date, are considered "older juveniles".

- *The Knights Landing Catch Index:* based on reported catch of older juveniles at the Knights Landing rotary screw trapping location and is calculated as the total catch of older juveniles (adjusted, as necessary, for partial cone operations) divided by the number of "trap days" (adjusted, as necessary, for downtime resulting from, for example, debris removal) since the last sampling event. This calculation for older juveniles/trap-day is implemented as [(total number of older juveniles/% cone sampling effort)/total hours fished)] * (24 hours fished/trap day).
- *The Sacramento Catch Index:* Both the Sacramento trawl (at Sherwood Harbor) and the Sacramento seine data are used to derive the Sacramento Catch Index. The reported catch of older juvenile Chinook salmon is used to generate a Sacramento Catch Index; a separate index for the seine data and a separate index for the trawl data.
    - The seine version of the catch index is standardized to eight hauls; therefore, the index is calculated as: (total number of older juveniles captured/# hauls) * 8. The Sacramento Seine route is based on eight sites: Verona, Elkhorn, Sand Cove, Discovery Park, American River, Miller Park, Sherwood Harbor, and Garcia Bend.
    - The trawl version of the catch index is standardized to 10 tows; therefore, the index is calculated as: (total number of older juveniles captured/# tows) * 10.

Table 3-7. Water Quality Levels of Concern Criteria (Simulated 14-day average Electrical Conductivity)

Station	Water Quality Concern Level (µmhos/cm)
Jersey Point	1800
Bethel Island	1000
Holland Cut	800
Bacon Island	700

µmhos/cm = micromhos per centimeter.

3.7.2.2 October 1 – November 30, Lower Mokelumne River Fall Closure

From October 1 through November 30, Reclamation proposes to close the DCC gates in addition to the requirements in D-1641 to enhance adult fall-run Chinook salmon passage into the Mokelumne River as described in Table 3-8. If the East Bay Municipal Utility District releases Lower Mokelumne River (LMR) attraction flows, water quality modeling shows concern level criteria (Table 3-7) are not likely to be exceeded for at least 14 days following the action, and there is no observed deterioration of interior Delta water quality, then Reclamation would close the DCC gates as soon as practicable (generally within 48 hours) for up to 5 days. Closure of the DCC gates when adult fall-run Chinook salmon attraction flows pass through the LMR can reduce straying of Chinook salmon between the Mokelumne and American rivers and increase the abundance of fall-run Chinook salmon returning to the Mokelumne River and its hatchery.

Table 3-8. Delta Cross Channel Action Triggers and Responses during Lower Mokelumne River (LMR) flow releases.

Action Triggers	Action Responses
• Water quality criteria per D-1641 are met and Real-time hydrodynamic; and • Salinity modeling shows water quality concern level targets are not exceeded during 14-day period following DCC closure; and • There is no observed deterioration of interior Delta water quality	Within 48 hours of start of LMR attraction flow release, close the DCC gates for up to 5 days
• Water quality criteria per D-1641 are met; and • Real time hydrodynamic and salinity modeling shows water quality concern level targets are exceeded during 14-day period following DCC closure	Reclamation and DWR, through Delta Monitoring Teams, review monitoring data and complete risk assessment to inform real-time operations of DCC gate closure.
• Water quality criteria are not met per D-1641	No DCC gate closure

3.7.2.3 December 1 – January 31

From December 1 to January 31, Reclamation proposes to close the DCC gates, except to avoid exceeding a D-1641 water quality criterion within the next 14 days based on water quality modeling (rather than increase releases and reduce reservoir storage further). Reclamation and DWR will prepare an assessment to evaluate opening the DCC gates for up to 5 days for up to two events within this period to avoid D-1641 water quality criteria exceedance. Reclamation and DWR will coordinate with USFWS, NMFS, CDFW and the State Water Board on how to balance D-1641 water quality and Endangered Species Act- (ESA) listed fish requirements and inform the Salmon Monitoring Team and Smelt Monitoring Team. The assessment will consider relevant monitoring information (e.g., upstream rotary screw traps, Delta juvenile fish monitoring surveys, Rio Vista flow standards, acoustic telemetered fish monitoring information) as well as potentially DSM2 modeling informed with recent hydrology, salinity, and tidal data. During these potential DCC gates openings, the CVP and SWP will limit combined exports as not to exceed 1,500 cfs, Health and Safety pumping level.

3.7.2.4 February 1 – May 20

Reclamation will keep the Delta Cross Channel Gates closed. State Water Board D-1641 requires the Delta Cross Channel Gates be closed.

3.7.2.5 May 21 – June 15

Reclamation will close the Delta Cross Channel Gates for a total of 14 days. Reclamation and DWR, through the Salmonid monitoring Team (SaMT), will prepare a plan that considers relevant information including: the upstream rotary screw traps, Delta juvenile fish surveys, Rio Vista flow standards, acoustic telemetered fish information, and DSM2 modeling. Reclamation typically schedules the Delta Cross Channel closures to occur on weekdays and keeps it open on weekends to accommodate recreational interests. State Water Board D-1641 requires the Delta Cross Channel to be closed for a total of 14 days after consultation with the USFWS, CDFW, and NMFS.

3.7.2.6 June 16 – September 30

From June 16 to September 30, Reclamation proposes to open the DCC gate.

3.7.3 Maintenance and Repair

The Reclamation Designers Operating Criteria, dated September 24, 1971, requires Reclamation to undertake routine maintenance and repair of the Delta Cross Channel Gates to continue reliable operation.[4] Certain routine maintenance and repair require cycling of the Delta Cross Channel Gates (i.e., open and close the gates several times in a row). Routine maintenance and repair will require cycling of one or both gates approximately twice per year for one day each. To avoid and minimize effects, Reclamation to the extent practicable will:

[4] Bureau of Reclamation. September 24, 1971. Reclamation Designers Operating Criteria.

- Perform cycling when federally listed fish are not likely present (mid-June through September)
- Perform cycling during daylight hours
- Minimize the duration of the time Delta Cross Channel is open during cycling when salmonids are present

Reclamation is required to maintain the Delta Cross Channel and may not have discretion over when the maintenance must occur. Reclamation will notify USFWS and NMFS of maintenance prior to its implementation, if it occurs during a closure period.

In addition:

1. As part of worker awareness training programs for federally listed species provided at the Delta Cross Channel facility, Tracy Fish Facility, Clifton Court Forebay facility and Barker Slough facility, Relamation will include information about Northwestern Pond Turtle.

2. If Northwestern Pond Turtle is observed to be in harm's way in and/ or adjacent to the Delta Cross Channel Facility, Tracy Fish Facility, Clifton Court Forebay Facility and Barker Slough, Reclamation and DWR will ensure turtles are moved to the nearest habitat and notify the USFWS within 72 hours of event.

3.7.4 Old and Middle River Flow Management

Old and Middle River flow management addresses the entrainment stressor on adult delta smelt, larval and juvenile Delta smelt, adult longfin smelt, larval and juvenile longfin smelt, winter-run juveniles, spring-run juveniles, steelhead juveniles, and green sturgeon. Old and Middle River (OMR) provides a surrogate indicator for how export pumping at Banks and Jones Pumping Plants influence hydrodynamics in the south Delta. OMR will be calculated using the equation provided in Hutton 2008. If an equation is developed that results in a better representation of OMR flows, and Reclamation, DWR, NMFS, USFWS, and CDFW agree, then that equation will be updated in calculating the OMR index.

3.7.4.1 Winter-Run Early Season Migration

Winter-Run Early Season Migration: To minimize entrainment and salvage of early-migrating natural older winter-run Chinook salmon, DWR and Reclamation will adjust exports to achieve a 7-day of the average OMR value no more negative than -5,000 cfs for seven consecutive days, to be assess on the seventh day of the averaging period after initiating operational changes in response to the OMR trigger, when the genetically verified 7-day rolling sum of winter-run Chinook salmon loss, calculated daily, exceeds the following annually calculated thresholds (see calculation details in Appendix I):

- From November 1 – November 30: 0.0044% (e.g., water year 2023) of the Red Bluff juvenile winter-run Chinook salmon Brood Year Total at the end of the second biweekly period in October, whereby the November Multiplier is:

  November Multiplier = 0.0011 x 0.25 x Survival*Fry-to-Smolt* x Survival*Smolt*

- From December 1 – December 31: 0.0084% (e.g., water year 2023) of the Red Bluff juvenile winter-run Chinook salmon Brood Year Total at the end of the second biweekly period in November, whereby the December Multiplies is:
    - December Multiplier = 0.0021 x 0.25 x Survival*Fry-to-Smolt* x Survival*Smolt*

If the 7-day rolling sum of winter-run and spring-run Chinook salmon loss, calculated daily, is exceeded during a period of reduced exports, DWR and Reclamation will continue to adjust exports to achieve a 7-day average of the OMR value no more negative than -5,000 cfs until 7 days after the most recent exceedance. Loss shall be calculated for the export facilities using the 2018 CDFW loss equation (Attachment R).

Reclamation and DWR will adjust exports in response of meeting the threshold above based on initial length-at-date identification of natural older juvenile Chinook salmon. If genetic analysis of natural older juvenile Chinook salmon observed in salvage at the SWP or CVP indicates that any given Chinook salmon is not genetically winter-run or spring-run Chinook salmon, these fish will not count towards the loss threshold exceedance, and continued export adjustments pursuant to the OMR limit may not be required. Given that SHERLOCK is a new methodology currently undergoing peer review and field testing, both methodologies will be used to determine the final identification. In the event that SHERLOCK and GT-seq provide different run assignments, the results from the GT-seq method will be used to determine the final run assignment for the purposes of implementing this early season migration action. If a fish is not genetically identifiable or if genetic identification is pending, then the Delta model length-at-date criteria shall be used to classify the race of the juvenile Chinook Salmon in salvage.

Spring-Run Chinook Salmon

Reclamation and DWR, through SaMT, will use real-time monitoring data, coupled with new science gained through ongoing efforts to develop a spring-run juvenile production estimate and life cycle model to inform weekly risk assessments (October through June) for natural-origin juvenile spring-run Chinook Salmon. If the risk assessment identifies a more positive OMR flow requirement is needed to minimize take of natural-origin juvenile spring-run Chinook Salmon, the WOMT may consider a more positive OMR flow requirement.

3.7.4.2 Start of OMR Management

The OMR management season starts any time after December 1 if an Adult Longfin Smelt Entrainment Protection Action, if appropriate (see Section 3.7.4.4.1, *Adult Longfin Smelt Entrainment Protection Action*), or First Flush Action occurs (i.e., immediately following completion of the First Flush Action) or any time after December 20 if the turbidity threshold in the Adult Delta Smelt Entrainment Protection Action is reached. If neither the Adult Longfin Smelt Entrainment Protection Action or First Flush Action occurs or the Adult Delta Smelt Entrainment Protection Action is reached, the OMR management season starts automatically on January 1. From the onset of OMR Management, Reclamation and DWR shall adjust the OMR index on a 14-day running average will be no more negative than -5,000 cfs until the end of the OMR management season. A reduction in exports to achieve a new OMR index will occur within three days of an action that requires a change in OMR.

First Flush Action: to minimize project influence on the movement of Delta smelt and potentially other listed fish species into the South Delta, Reclamation and DWR will adjust CVP and SWP exports for 14 consecutive days, to be assess on the seventh day of the averaging period after initiating operational changes in response to the OMR trigger, anytime between December 1 and the last day of February, to maintain a 14-day average of the OMR index no more negative than -2,000 cfs within three days of when the following criteria are met:

- Three-day running average of daily flows at Freeport is greater than, or equal to, 25,000 cfs, and
- Three-day running average of daily turbidity at Freeport is greater than, or equal to, 50 Formazin Nephelometric Units (FNU)

These criteria will be evaluated using data from the California Data Exchange Center Sacramento River at Freeport. The First Flush Action may only be initiated once each water year. The First Flush Action is exempt from the high-flow offramps as outlined below.

Reclamation and DWR, through WOMT, may prepare an assessment to initiate the First Flush Action early if real-time monitoring of abiotic and biotic factors and salvage prediction models indicates the First Flush Action is likely to be triggered (i.e., within two to three days) and delta smelt salvage is possible.

Reclamation and DWR recognize that readings at individual turbidity sensors or localized groups of turbidity sensors can generate spurious results in real-time. To avoid triggering an OMR flow action during a sensor error or a localized turbidity spike that might be caused by local flows or a wind-driven event, Reclamation and DWR will consider and review data from other locations. In the event that the three-day running average of daily turbidity at Freeport is 50 FNU (or greater), and Reclamation and DWR believe that a First Flush action is not warranted based on additional data sources, DWR and Reclamation will provide the additional data to the Smelt Monitoring Team (SMT) and request they convene to confirm criteria will be met because of increased precipitation rather than sensor error or localized turbidity spike. If it is determined through WOMT that there is sensor error or a localized turbidity spike, Reclamation and DWR will take no additional action and provide the supporting information to the Service and CDFW within 24 hours.

A reduction in exports to achieve a new OMR index will occur within three days of an action that requires a change in OMR.

Once an OMR action is triggered, combined project exports will not be increased, except as scheduled prior to the trigger with notice to WOMT, in a manner that would make projected OMR more negative. Export reductions to meet the conditions of the trigger will be done using the normal scheduling procedure. Combined projected exports, export scheduling, and OMR will be discussed at WOMT each week. The intent is that combined project exports will not increase the risk to protected fish species after an OMR trigger is met.

3.7.4.3 Real-time Adjustments

Reclamation and DWR will manage to a more positive OMR than -5,000 cfs on a 14-day average under the following conditions:

3.7.4.4 Adult Delta Smelt Entrainment Protection Action (Turbidity Bridge)

The purpose of this action is to minimize adult Delta smelt entrainment risk by reducing exports during periods when turbidity is elevated in the south Delta resulting in habitat conditions that support movement of Delta smelt from the lower San Joaquin River into the south Delta and toward the export facilities (Smith et al. 2021). If after a First Flush Action or after December 20, whichever occurs first, daily average turbidity remains or becomes elevated to 12 FNU or higher at each of three turbidity sensors in the OMR corridor creating a continuous bridge of turbidity from the lower San Joaquin River to the CVP and SWP export facilities, Reclamation and DWR will adjust exports to achieve a five-day average of the OMR flow that is no more negative than -3,500 cfs, to be assess on the seventh day of the averaging period after initiating operational changes in response to the OMR trigger, until the daily average turbidity in at least one of the three turbidity sensors is less than 12 FNU for two consecutive days, thereby indicating a break in the continuous bridge of turbidity. The three turbidity sensors are Holland Cut, Old River at Bacon Island, and Old River at Frank's Tract near Terminous.

If the three turbidity sensors remain over 12 FNU at the end of a High Flow Off-Ramp or any time after five consecutive days, then Reclamation and DWR, through WOMT, may prepare an assessment to determine if another Adult Delta Smelt Entrainment Protection Action is warranted based on continued entrainment risk following the period of elevated flows and whether delta smelt distribution has shifted downstream, as informed by available quantitative tools and real-time data.

The Adult Delta Smelt Entrainment Protection Action ends when the three-day continuous average water temperatures at Jersey Point or Rio Vista reach 53.6ºF (12ºC).

When daily average San Joaquin River flows at Vernalis are greater than 10,000 cfs, the Adult Delta Smelt Entrainment Protection Action (Turbidity Bridge) is offramped. While offramped, the OMR Index will be managed to no more negative than –5,000 cfs on a 14-day average. The Adult Delta Smelt Entrainment Protection Action (Turbidity Bridge) would be immediately reinstated when daily average San Joaquin River flows at Vernalis drop below 8,000 cfs.

3.7.4.4.1 Adult Longfin Smelt Entrainment Protection Action

If cumulative water year salvage of Longfin smelt with fork length ≥ 60 mm at the CVP and SWP facilities exceeds the savage threshold, where:

$$Salvage\ threshold = \left(\frac{Age\ 1 + Longfin\ smelt\ index^{\square}}{20}\right) + 1$$

Where:

- The Age 1 + LFS index is calculated using age 1+ fish captured in the mid water trawl from the full San Francisco Bay Study sampling area (California Department of Fish and Game 1999). The Age 1 + LFS index is additive for the months of August, September, October, November, and December. If December data is not available at the start of this action period, then the August to November threshold will be used until the December data is available and the complete Age 1 + LFS Index is calculated.

Then:

- From December 1 to the start of the OMR management season, Reclamation and DWR shall adjust exports to achieve an OMR flow no more negative than -5,000 cfs on a seven-day average for seven consecutive days, to be assess on the seventh day of the averaging period after initiating operational changes in response to the OMR trigger, and then, if appropriate, initiate the start of OMR management season. During the 7-day period, WOMT may convene and determine if initiation of OMR management season is warranted. If WOMT determines initiating OMR management is not warranted, the OMR management season does not begin at the conclusion of the 7-day period. If salvage of Longfin smelt ≥ 60 mm continues following the 7-day period where OMR is no more negative than -5,000 cfs, then Reclamation and DWR, through WOMT, may prepare an assessment to determine if additional Longfin smelt entrainment protection action is warranted based on continued entrainment risk, as informed by available quantitative tools and real-time data. WOMT may determine if OMR management should be initiated. If WOMT does not meet then protections will be initiated.
- From the start of the OMR management season to the end of February, Reclamation and DWR shall operate to an OMR flow no more negative than -3,500 cfs on a seven-day average for seven consecutive days, to be assess on the seventh day of the averaging period after initiating operational changes in response to the OMR trigger. If salvage of Longfin smelt ≥ 60 mm continues following the 7-day period where OMR is no more negative than -3,500 cfs, then Reclamation and DWR, through WOMT, may prepare an assessment to determine if additional Longfin smelt entrainment protection action is warranted based on continued entrainment risk, as informed by available quantitative tools and real-time data.

3.7.4.5 Larval and Juvenile Delta Smelt Protection Action

Larval and juvenile Delta smelt protections start upon the end of the Adult Delta Smelt Entrainment Protection Action. Reclamation and DWR will operate south Delta exports to a 7-day average of the OMR index no more negative than -5,000 cfs when the average Secchi disk depth in the most recent survey is greater than one meter. The Secchi disk depth will be calculated as the average measurement from all sampled stations on the San Joaquin River upstream of Jersey Point and stations south of the lower San Joaquin River. If the average Secchi disk depth in the most recent survey is less than 1 meter, then Reclamation and DWR will operate to a 7-day average of the OMR index no more negative than -3,500 cfs until the average Secchi depth has increased to more than 1 meter. The projects will operate to whichever of these OMR thresholds is appropriate given the latest Secchi disk depth data until the End of OMR Management Season.

3.7.4.5.1 Larval and Juvenile Longfin Smelt Protection Action

From January 1 through the end of OMR management season (see below), if:

- The 7-day average QWest is < +1,500 cfs (as calculated using the Dayflow QWest equation), and;

- Larval and juvenile Longfin smelt catch in the most recent Smelt Larva Survey (SLS) and 20mm survey at stations 809 and 812 exceeds the catch threshold set by the Age 1 + LFS Index as described in Table 3-10, for catch thresholds.

Reclamation and DWR will adjust the 7-day average the OMR flow to no more negative than -3,500 cfs for seven days, to be assess on the seventh day of the averaging period after initiating operational changes in response to the OMR trigger. Upon initiation of the action DWR and Reclamation, through WOMT, may prepare an assessment to determine if the 7-day action can be adjusted or off ramped based on larval and juvenile LFS entrainment risk, as informed by available quantitative tools and real-time data. If off ramped, the Larval and Juvenile Longfin Smelt Protection Action shall later be retriggered if conditions warrant.

If the WY cumulative juvenile Longfin smelt salvage at the CVP and SWP facilities exceeds 50% of the average annual salvage observed from 2009 through the water year preceding the current water year, then Reclamation and DWR shall adjust to a seven-day average of the OMR of -3,500 cfs for 14 days, to be assess on the seventh day of the averaging period after initiating operational changes in response to the OMR trigger. If the WY cumulative juvenile Longfin smelt salvage at the CVP and SWP facilities during this period exceeds 75% of the average annual salvage observed from 2009 through the water year preceding the current water year, then Reclamation and DWR shall adjust to a 7-day average of the OMR of -2,500 cfs for 14 days, to be assess on the seventh day of the averaging period after initiating operational changes in response to the OMR trigger. If salvage of larval and juvenile Longfin Smelt continues following the 14-day period where OMR is no more negative than -2,500 cfs, then WOMT may request Reclamation and DWR, through the SMT, a risk assessment on appropriate OMR flows through the remainder of the OMR Management.

Table 3-9. San Francisco Bay Study Longfin Smelt Index Catch Threshold

San Francisco Bay Study Longfin smelt index[1]	Catch Threshold at 809 & 812
0 – 149	10
150 – 299	20
300 – 499	30
500 – 999	40
≥ 1000	50

3.7.4.5.2 High-Flow offramps for Larval and Juvenile Delta smelt and Longfin smelt

When the daily average Sacramento River flows at Rio Vista are greater than 55,000 cfs, or San Joaquin River flows at Vernalis are greater than 8,000 cfs, then the Larval and Juvenile Delta smelt and Longfin smelt Protection Actions are offramped. While offramped, the OMR Index will be managed to no more negative than –5,000 cfs on a 14-day average. The Larval and Juvenile Delta smelt and Longfin smelt Protection Actions would be immediately reinstated when the daily average Sacramento River flows at Rio Vista drop below 40,000 cfs or the San Joaquin River flows at Vernalis drop below 5,000 cfs. Rio Vista flows are calculated from the Dayflow equation and reported in the daily DWR Delta Hydrologic Conditions Report.

3.7.4.5.3 Winter-Run Chinook Salmon Annual Loss Threshold

Reclamation and DWR will manage OMR to avoid exceeding the following annual loss thresholds:

- Natural winter-run Chinook salmon (loss = 0.5% of JPE)
- Hatchery winter-run Chinook salmon (loss = 0.12% of JPE)

JPEs and annual loss thresholds will be calculated for natural winter-run Chinook and for each of the hatchery winter-run Chinook Salmon populations from LSNFH and Battle Creek. The JPE for natural and hatchery winter-run Chinook salmon will be calculated at least annually by the JPE SubTeam, as described in Appendix- Winter-Run Juvenile Production Estimate, and transmitted to WOMT and SHOT. Hatchery releases of winter-run Chinook salmon will be tracked individually, and cumulative loss will be summed across release groups with the same JPE and annual loss threshold. Loss shall be calculated for the export facilities using the 2018 CDFW loss equation (Attachment R).

Annual loss of natural and hatchery winter-run Chinook salmon at the CVP and SWP salvage facilities will be counted for each Brood Year, starting July 1 of the calendar year through June 30 of the following calendar year. If cumulative loss of natural or hatchery winter-run Chinook salmon in a brood year exceeds 50% of the annual loss thresholds, then DWR and Reclamation will adjust south Delta exports to maintain a 7-day average of the OMR value no more negative than -3,500 cfs for 7 consecutive days, to be assess on the seventh day of the averaging period after initiating operational changes in response to the OMR trigger. Once exceeded, each winter-run observed in salvage would trigger another operation to an OMR limit of -3,500 cfs for 7 days.

If the cumulative loss of natural or hatchery winter-run Chinook salmon in a brood year exceeds 75% of the annual loss thresholds, then DWR and Reclamation will adjust south Delta exports to maintain a 7-day average of the OMR value no more negative than the -2,500 cfs for seven consecutive days, to be assess on the seventh day of the averaging period after initiating operational changes in response to the OMR trigger, when the Winter-Run Chinook Salmon Machine Learning Model and associated OMR Conversion Tool predict that the change to -2,500 cfs will shift the model output to a classification of absence with a minimum probability of absence prediction of 0.559 for 1 of 30 sub-models for any of the 7 most recent prediction days. These prediction values are calculated based on length-at-date and will be updated once genetic analysis is fully adopted.

If the cumulative loss of either natural or hatchery-origin winter-run Chinook Salmon in a brood year exceeds 100 percent of the annual loss thresholds, then DWR and Reclamation will immediately convene the Salmon Monitoring Team (SaMT) to review recent fish distribution information and operations and provide advice regarding future planned SWP and CVP operations to minimize subsequent loss during that year. The SaMT will report the results of this review and advice to the WOMT. Operational decisions will be made following the process described in Section 3.3.18, Governance. If either annual loss threshold is exceeded, DWR and Reclamation will also convene an independent peer review panel to review SWP and CVP operations and the annual loss thresholds prior to November 1. The purpose of the independent

peer review is to review the actions and decisions contributing to the loss trajectory that led to an exceedance of an annual loss threshold, and make recommendations on modifications to SWP and CVP operations, or additional actions to be conducted to stay within the annual loss thresholds in subsequent years.

Reclamation and DWR will restrict exports in response to meeting the above thresholds based on the initial length-at-date identification of natural older juvenile Chinook salmon and the thresholds described above. If genetic analysis of natural older juvenile Chinook salmon observed in salvage at the SWP or CVP indicates that any given Chinook salmon is not genetically winter-run Chinook salmon, these fish will not count towards annual the loss threshold exceedance, and continued export adjustments pursuant to the OMR limit may not be required. Given that SHERLOCK is a new methodology currently undergoing peer review and field testing, both methodologies will be used to determine the final identification. In the event that SHERLOCK and GT-seq provide different run assignments, the results from the GT-seq method will be used to determine the final run assignment for the purposes of implementing this early season migration action. If a fish is not genetically identifiable or if genetic identification is pending, then the Delta model length-at-date criteria shall be used to classify the race of the juvenile Chinook Salmon in salvage.

3.7.4.5.4 Winter-Run Chinook Salmon Weekly Distributed Loss Threshold

To minimize the potential for a disproportionate impact of entrainment on any single week of natural winter-run Chinook salmon present in the Delta, Reclamation and DWR will manage the OMR index based on a weekly distributed loss threshold. There is no weekly distributed loss for hatchery winter-run Chinook salmon as they generally move through the Delta quickly.

The weekly loss threshold is a product of the weekly percentage of natural winter-run Chinook salmon present in the Delta, scaled to 100% (Table 3-11, Column E), and 50% of the natural winter-run annual loss threshold.

If the weekly distributed loss threshold is exceeded on any single day by the 7-day rolling sum of winter-run loss, then DWR and Reclamation will adjust exports to achieve a 7-day average of the OMR no more negative than -3,500 cfs for seven consecutive days. Loss shall be calculated for the export facilities using the 2018 CDFW loss equation (Attachment R).

The averaging period for OMR will begin within 3 days of a criterion being exceeded.

If a JPE is not available at the start of OMR management, then the RBDD Brood Year Total from the most recent bi-weekly period will be used and applied, as described for early season management. If a fish is not genetically identifiable or if genetic identification is pending, then the length-at-date identification will be used to classify the race of the juvenile Chinook salmon in salvage.

Weekly thresholds will be based on historical distribution (Table 3-11, Column E) of genetically identified winter-run Chinook salmon from 2017-2021 and change every week (e.g., January 1-7, January 8-15). Each week, Reclamation and DWR, through SaMT, will compare weekly Delta entry and exit information to determine if the present data is tracking with the historical distribution data. Reclamation and DWR, through SaMT, may adjust subsequent weekly loss

thresholds based on year-specific conditions. At the conclusion of the OMR management season, Reclamation and DWR will review and may adjust the historical distribution table, through SaMT, for the following year.

DWR and Reclamation, initially, will restrict exports in response to meeting the above thresholds based on the initial length-at-date identification of natural-origin older juvenile Chinook Salmon and the thresholds described above. If genetic analysis of natural-origin older juvenile Chinook Salmon observed in salvage at the SWP or CVP subsequently indicates that any given Chinook Salmon is not genetically identified as a winter-run Chinook Salmon, these fish will not count towards the loss threshold exceedance, and continued export adjustments pursuant to the OMR index limit may not be required. While the new method, SHERLOCK, undergoes field testing, both it and the current GT-seq method will be used to determine the final identification. In the event that SHERLOCK and GT-seq provide different run assignments, the results from the GT-seq method will be used to determine the final run assignment. If a fish is not genetically identifiable or if genetic identification is pending, then the Delta model length-at-date criteria shall be used to classify the race of the juvenile Chinook Salmon in salvage.

Table 3-10. Historical (Water Years 2017–2021) Presence of Winter-run Chinook Salmon Entering the Delta (Column B), Exiting the Delta (Column C), in the Delta (Column D = Column B–Column C) and in the Delta Scaled to 100% (Column E)

Week (starting January 1) (A)	Historical Cumulative entering the Delta (Sherwood Harbor) (B)	Historical Cumulative exiting the Delta (Chipps Island) (C)	Historical Present in Delta (D)	Historical Present in Delta (Scaled to 100%) (E)
1/1–1/7	2.47%	1.65%	0.82%	0.32%
1/8–1/14	2.47%	1.65%	0.82%	0.32%
1/15–1/21	4.94	1.65%	3.29%	1.30%
1/22–1/28	4.94%	1.65%	3.29%	1.30%
1/29–2/4	19.75%	2.20%	17.55%	6.91%
2/5–2/11	38.27%	4.95%	33.32%	13.13%
2/12–2/18	43.21%	5.49%	37.72%	14.86%
2/19–2/25	46.91%	9.89%	37.02%	14.59%
2/26–3/4*	50.62%	18.13%	32.49%	12.80%
3/5–3/11	55.56%	30.77%	24.79%	9.77%
3/12–3/18	77.78%	38.46%	39.32%	15.49%
3/19–3/25	85.19%	64.84%	20.35%	8.02%
3/26–4/1	93.83%	90.11%	3.72%	1.47%
4/2–4/8	98.77%	99.45%	0%	0%
4/9–4/15	100.00%	100.00%	0.00%	0.00%
4/16-End of Winter–run OMR Season	100.00%	100.00%	0.00%	0.00%

Notes: Data from genetically identified winter-run Chinook salmon entering the Delta (Sherwood Harbor Trawl) and exiting the Delta (Chipps Island Trawl) are used to estimate the percentage of winter-run Chinook salmon present in

the Delta each week. Presence prior to January 1 each year is included in the first week of presence.
* The week of 2/26–3/4 includes 8 days during leap years

3.7.4.5.5 Steelhead Annual Threshold

In each year, Reclamation and DWR will manage exports to reduce loss at the CVP and SWP salvage facilities. To support survival and decrease entrainment loss, Reclamation and DWR will manage OMR to avoid exceeding the following annual loss threshold at CVP and SWP salvage facilities through the weekly distributed loss threshold described below.

- Unclipped juvenile California Central Valley steelhead loss = 3,000

Annual loss of unclipped juvenile CCV steelhead at the CVP and SWP salvage facilities will be counted cumulatively for each Brood Year, starting July 1st of the calendar year through June 30th of the following calendar year. Loss will be calculated for the South Delta Export Facilities using CDFW's steelhead loss multiplier until a loss method for steelhead (see Section 3.11.1 is approved by CDFW and NMFS. This loss threshold will be used until a new loss threshold is developed through the steelhead JPE Special Study (See Section 3.11.1).

3.7.4.5.6 Steelhead Weekly Distributed Loss Threshold

To minimize the potential for a disproportionate impact of entrainment of steelhead present in the Delta on any single week, Reclamation and DWR will manage OMR based on a weekly distributed loss threshold. The weekly loss threshold is the annual loss threshold distributed over the period of observed steelhead salvage between January 1 and June 30 using the 7-day weekly periods identified in the weekly distributed loss table for winter-run Chinook salmon, extended through June 30. DWR and Reclamation will reduce exports to achieve a 7-day average OMR value no more negative than -3,500 cfs for seven consecutive days when the 7-day rolling sum of steelhead salvage, calculated daily, exceeds the weekly loss threshold of 120 fish.

3.7.4.5.7 Spring-Run Chinook Salmon and Surrogate Thresholds

To provide additional minimization protection for emigrating natural juvenile spring-run Chinook salmon from the Sacramento River and tributaries, including the Feather and Yuba rivers, into the channels of the central Delta, south Delta, and into SWP and CVP south Delta pumping facilities, DWR and Reclamation will restrict exports based on the presence of hatchery produced spring-run and associated yearling late-fall-run and young-of-year fall-run Chinook salmon surrogate groups at the CVP and SWP salvage facilities. DWR and Reclamation, in coordination with CDFW, NMFS, and USFWS through the SaMT, will select spring-run yearling and young-of-year surrogate groups. Yearling spring-run surrogates will be selected from late-fall Chinook salmon in-river release groups from the Coleman National Fish Hatchery. Spring-run young-of-year and associated surrogate groups will be selected from fall- and spring-run Chinook salmon in-river release groups from the Feather River Fish Hatchery and Coleman National Fish Hatchery.

From November 1 through the end of the OMR flow management period of each water year, if a cumulative loss threshold is exceeded for surrogate release group, Reclamation and DWR will adjust south Delta exports to achieve a 7-day average of the OMR index of no more negative than -5,000 cfs in November and December, and no more negative than -3,500 cfs beginning January 1 (or whenever the OMR management begins) through the end of OMR flow management season, or June 30, whichever occurs first. The cumulative loss threshold for coded wire tagged spring-run Chinook salmon surrogate groups at the CVP and SWP salvage facilities is 0.25% for each release group:

- Yearling spring-run Chinook salmon surrogates: WOMT, with input from SaMT, will select three in-river releases of late-fall Chinook salmon from Coleman National Fish Hatchery from November through February to use as yearling spring-run Chinook salmon surrogates. Input from SaMT could include a proposal with several alternatives. If three in-river releases appropriately distributed from November through February are not achievable in a given year because of hatchery limitations, then an alternative plan will be developed to ensure the adequate characterization of natural yearling spring-run Chinook salmon can still be achieved that year.
- Young-of-year spring-run Chinook salmon surrogates: WOMT, with input from SaMT, will select six in-river releases comprised of spring-run and fall-run Chinook salmon from the Feather River Fish Hatchery and fall-run Chinook salmon from the Coleman National Fish Hatchery from March through May to use as young-of-year spring-run Chinook salmon surrogates. Input from SaMT could include a proposal with several alternatives. If six in-river releases appropriately distributed from March through May are not achievable in a given year because of hatchery limitations, then an alternative plan will be developed to ensure the adequate characterization of natural origin young-of-year spring-run Chinook salmon can still be achieved that year.

Loss shall be calculated for the export facilities using the 2018 CDFW loss equation (Attachment R). The surrogate methods are intended to be an interim measure that will be replaced with a measure as described in Section 3.11.2, *Spring-Run Juvenile Production Estimate and Life Cycle Model*.

3.7.4.6 Storm-Flex

During the OMR management season, Reclamation and DWR, through WOMT, may prepare an assessment to evaluate operating to an OMR index no more negative than -6,250 cfs between the start of OMR management season and the larval and juvenile Delta Smelt Protection Action onramp, or the last day of February, whichever occurs first, to capture peak flows during storm-related events when:

1. The Delta is in excess conditions as defined in the 1986 Coordinated Operations Agreement, as amended in 2018; and
2. QWEST is greater than +1,500 cfs; and
3. X2 is <81km; and

4. The daily average turbidity at the Holland Cut, Old River at Bacon Island, and Old River at Frank's Tract sensors are < 12 FNU at each station; and

5. A measurable precipitation event has occurred in the Central Valley; and

6. Reclamation and DWR determine that the net Delta outflow index indicates a higher level of outflow available for diversion due to peak storm flows; and

7. None of the additional real-time OMR protections are controlling Project operations; and

8. Cumulative loss of the CVP and SWP export facilities of yearling Coleman National Fish Hatchery late-fall run chinook salmon (yearling spring run chinook salmon surrogate) is less than 0.5% within any of the release groups.

If the criteria above are met, WOMT will decide whether to request that DWR and Reclamation use estimates of the real-time distribution of listed-species from SMT and SaMT, as well as Particle Track Model (PTM) and prediction tool output to assess potential listed-species entrainment risk differences using OMR inputs of -5000 and –6250 cfs. If the assessment indicates that no additional real-time OMR protections for the upcoming week are likely to be triggered, Reclamation and DWR will bring a request back to WOMT for approval to operate to OMR no more negative than -6,250 cfs and will update the assessment no less than weekly.

If conditions indicate an additional real-time OMR protection is likely to trigger, Reclamation and DWR will adjust south Delta exports to achieve a 14-day average of the OMR index no more negative than -5,000 cfs, unless a further reduction in exports is required. If an entrainment protection condition is triggered, Reclamation and DWR will cease storm-flex and implement the entrainment protection condition. Storm-flex decisions will be re-evaluated weekly by WOMT.

3.7.4.7 End of OMR Management Season

OMR Management season for Delta smelt and Longfin smelt will conclude when the three consecutive days of daily mean water temperature at Clifton Court Forebay is 77.0°F (25°C) or higher, or on June 30, whichever occurs first.

Reclamation and DWR will conclude the management of OMR for salmonids on June 30 or when the following conditions have occurred, whichever occurs first:

- Daily mean water temperature at Mossdale has exceeded 71.96°F (22.2°C) for 7 non-consecutive days (does not have to be consecutive) in June; and
- Daily mean water temperature at Prisoner's Point has exceeded 71.96°F (22.2°C) for 7 non-consecutive days (does not have to be consecutive) in June.

3.7.4.8 End of Year Evaluation

Each year, DWR and Reclamation, in coordination with the SMT, will conduct an annual assessment of OMR protection measures for Delta smelt and longfin smelt, which will include an evaluation of salvage, management actions, and physical conditions in a seasonal report. This seasonal report may support improvements, if necessary, to the OMR Guidance Document, and may also guide operations in the future. This seasonal report will fulfill commitments under the ROD that will be signed by Reclamation on the Consultation on the Coordinated Long-Term Operation of the CVP and SWP to produce a seasonal report each year. Additionally, this seasonal report will be used to support the development of Reclamation's Annual Report on the Long-Term Operation of the Central Valley Project and State Water Project. Finally, this seasonal report will inform any Four-Year Review Panels adopted under the ROD. The purpose of the independent review will be to evaluate the efficacy of actions undertaken to reduce the adverse effects on listed species.

Each year, DWR and Reclamation, in coordination with the SaMT, will conduct an annual assessment of OMR protection measures for winter-run Chinook salmon, spring-run Chinook salmon, and steelhead, which will include an evaluation of salvage, management actions, and physical conditions. in a seasonal report. This seasonal report may support improvements, if necessary, to the OMR Guidance Document, and may also guide operations in the future. This seasonal report will fulfill commitments under the ROD that will be signed by Reclamation on the Consultation on the Coordinated Long-Term Operation of the CVP and SWP to produce a seasonal report each year. Additionally, this seasonal report will be used to support the development of Reclamation's Annual Report on the Long-Term Operation of the Central Valley Project and State Water Project Finally, this seasonal report will inform any Four-Year Review Panels adopted under the ROD. The purpose of the independent review will be to evaluate the efficacy of actions undertaken to reduce the adverse effects on listed species.

3.7.5 Spring Delta Outflow

Reclamation and DWR will take actions intended to supplement Delta outflow per the terms of the VAs. Actions that will support the additional Delta outflow include the following: Reclamation and DWR south of Delta export modifications; Reclamation reoperating upstream reservoirs to advance and allow for scheduling of water made available by contractors in CVP watersheds; and passing Delta inflow from water made available by VA Parties. Actions to result in increased Delta outflow are shown in Table 3-12. These volumes (and associated footnotes) are reflected in the Memorandum of Understanding signed by VA parties in March 2022.

Table 3-11. Water Made Available by the CVP and SWP[5]

	Critical (TAF)	Dry (TAF)	Below Normal (TAF)	Above Normal (TAF)	Wet (TAF)
SWP and CVP Forgone Exports[6]	0	125	125	175	0
SWP Flow Purchases Implemented through Forgone SWP exports	0	30	30	30	0
SRSC Fallowing[7]	2	102	100	100	0
Sac. Valley Purchase[8]	0	10	10	10	0
American River Groundwater and Reoperation of Upstream Reservoirs[9]	30	40	10	10	0
CVP SOD Purchase[10]	0	12.5	24.5	35	0
Westlands Contract Assignment Purchase[11]	3	6	15	19.5	27
Additional CVP SOD[12]	0	5	5	5	0
San Joaquin River Flows above Tributary VAs	0	50	50	50	0
Flow Purchases Acquired Through SWP Diversion Fees (implemented through tributary inflow from the fallowing program)[13]	0	45	45	45	0

[5] These numbers are set forth in the Term Sheet, Appendix 1. Flow Tables

[6] Subject to Public Health and Safety exports of 1,500 cfs.

[7] SRSC will fallow 25,000 acres of rice which is credited with 110 TAF, which includes 10 TAF of fixed price purchase water. Dry year water may be held in Shasta for storage to improve temperature management in the current or future years. 2TAF in Critical and Dry years are contributions from Mill/Cow Creek.

[8] The new flow contributions from the Sacramento River Basin identified in this Table 3-12, plus new flow contributions resulting from the below-referenced PWA Water Purchase Program, Permanent State Water Purchases, and PWA Fixed Price Water Purchase Program line items in Table 3-12, are not intended to result in idling more than 35,000 acres of rice land in the Sacramento River Basin.

[9] Contingent on public funding of groundwater substitution infrastructure to be completed by a subsequent year, and compensation of upstream surface storage releases on a per acre-foot basis. These flows are included in the Year 1 subtotal. Only implementable in 3 of 8 Dry or Critical years and 3 of 8 Above Normal or Below Normal years.

[10] Subject to CVP SOD Agricultural Allocation.

[11] Quantity of water made available will be based on the maximum or a portion of the entitlement under certain assignment contracts and only that which is allocated to CVP SOD Agriculture.

[12] If flows are not obtained through this source, the equivalent volume would be obtained at market price or otherwise obtained through other mechanisms.

[13] The VA's governance program will be used to determine the use of available funding to provide additional outflow in AN, BN, or W years. If DWR is called upon to provide the water by foregoing SWP exports, such call will be handled through a separate agreement between DWR and its contractors. The numbers for "Flow Purchases Acquired Through SWP Diversion Fees (implemented through tributary inflow from the fallowing program)" are the SWP's partial contributions to the total values set forth in the Term Sheet, Appendix 1 under the PWA Water Purchase Program's fallowing contributions for AN, BN and D years.

	Critical (TAF)	Dry (TAF)	Below Normal (TAF)	Above Normal (TAF)	Wet (TAF)
Total CVP and SWP Outflow Potentially through CVP and SWP Operations[14]	33	423.5	414.5	478.5	27
Additional Feather River Actions accounted for under Total VA Outflow (below)		60	60	60	
Total VA Outflow by All VA Parties	155	825.5	750.5	824.5	150

Reclamation and DWR will operate consistent with the Voluntary Agreements approved by the SWRCB and executed agreements by VA Parties.

Reclamation Early Implementation: Reclamation, after coordination through WOMT, will provide the CVP Foregone Exports, along with other VA parties taking actions similar to those contemplated by the VAs only if: (i) Reclamation issues a Record of Decision for the coordinated operation of the CVP and SWP that are the subject of the consultation, and (ii) the SWRCB has not updated the Water Quality Control Plan. These early implementation actions are intended to develop data that could assist decisions whether to implement the VAs or decisions how to implement the VAs. Delta outflow from Reclamation actions described above would be in March through May and prioritized during the period of April 1 through May 31. These early implementation actions will continue until the SWRCB updates the Water Quality Control Plan or for two years, whichever occurs first.

Reclamation Post Early Implementation: After Reclamation's two-year early implementation period:

- Reclamation will operate consistent with the VAs only if (a) the SWRCB approves the VAs, as substantially proposed by the VA parties, and (b) the VA parties execute or are in the process of executing the agreements contemplated by the VAs, or
- Reclamation will operate as described by the alternative but without any of the actions contemplated for "early implementation" of the VAs if (i) the SWRCB does not incorporate the VAs, as proposed by the VA parties, into the Water Quality Control Plan, or (ii) the VA parties do not execute the agreements contemplated by the VAs.

DWR Implementation: DWR will operate pursuant to Section 3.3.3.2 Early Voluntary Agreement Implementation of their *November 2023 Incidental Take Permit Application, Long-Term Operations of the State Water Project*. DWR's early implementation actions will continue until the SWRCB approves the VAs.

[14] The volumes identified in this row represent the CVP and SWP contributions. Additional flows from other VA parties and Permanent State Water Purchases will increase Delta Outflow.

3.7.6 Delta Smelt Summer and Fall Habitat

3.7.6.1 Fall X2

To increase the amount of low salinity zone habitat for Delta Smelt, in Wet and Above Normal hydrologic year types, Reclamation and DWR will maintain a 30-day average X2 ≤ 80km for September through October.

3.7.6.2 Suisun Marsh Salinity Control Gate

To address effects on critical habitat for juvenile Delta Smelt and increase habitat and food access for Delta Smelt in summer and fall (June through October) in Suisun Marsh and Grizzly Bay during above normal, below normal, and dry years following wet or above normal years, DWR will operate SMSCG for 60 days, to maximize the number of days that Belden's Landing three-day average salinity is equal to, or less than, 4 practical salinity units (psu) to maximize the spatial and temporal extent of Delta Smelt low salinity zone habitat in Suisun Marsh and Grizzly Bay. Operation of the SMSCG will occur between June 1 and October 31 in years which operation of the SMSCG is required. In dry years following below normal years, DWR will operate SMSCG for 30 days to maximize the number of days Belden's Landing three-day salinity is equal to, or less than 6 psu to maximize the spatial and temporal extent of Delta Smelt low salinity zone habitat in Suisun Marsh and Grizzly Bay. DWR and Reclamation, through the Delta Coordination Group (DCG), may prepare an assessment to propose an alternative gate operation if modeling of hydrological and/or existing D-1641 conditions indicate the action can achieve the same habitat benefits in an equal or better manner within the range of effects analyzed. Subsequently, DWR and Reclamation may propose alternative operations of the SMSCG for WOMT to consider prior to May 15 of each year a SMSCG action will be required. DWR and Reclamation, through the DCG, will develop a monitoring plan that responds to uncertainties in the performance metrics to evaluate action performance based on a schedule determined by the Adaptive Management Steering Committee (AMSC). DWR and Reclamation will also produce a report that summarizes monitoring findings and assess action performance based on a schedule determined by the AMSC. The Summer-Fall Habitat Action (SFHA) shall be included in independent reviews under the adaptive management program.

3.7.7 Tracy Fish Collection Facility

The Tracy Fish Collection Facility addresses the entrainment stressor. Reclamation will operate the Tracy Fish Collection Facility to screen fish from Jones Pumping Plant. The primary channel is a behavioral barrier with effectiveness that depends on the pumping Jones Pumping Plant. The secondary channel is a positive fish barrier. When south Delta hydraulic conditions allow and conditions are within the original design criteria for the Tracy Fish Collection Facility, the secondary channel is operated to achieve water approach velocities for striped bass of approximately 1 to 2.5 feet per second from June 1 through October 31 and for salmon of approximately 3 feet per second from November 1 through May 31.

Salvage of fish at the Tracy Fish Collection Facility occurs 24 hours per day, 365 days per year. Fish are salvaged in flow-through holding tanks, monitored by a 30-minute fish count every 120 minutes, and transported by truck to release sites near the confluence of the Sacramento and San Joaquin Rivers. Larval smelt sampling commences upon detection of a spent female at Tracy Fish Collection Facility or Skinner Fish Facility or when a temperature trigger of 53.6°F (12°C)

at nearby California Data Exchange Center stations is met. Salvage and operations data necessary to calculate loss are made available daily by 10 a.m. The standard operating procedures for the Tracy Fish Collection Facility are included in Attachment T.

To seek additional improvements to the operating procedures and reporting of the Tracy Fish Collection Facility; Reclamation proposes to develop the Alternative Loss Pilot Study Implementation Plan (ALPS-IP) and implement the resulting pilot study, which would include consideration of additional salvage facility loss parameterization and study or further procedural modifications if identified and prioritized through the ALPS-IP Structured Decision Making (SDM) results and would result in demonstrated improvements to the accuracy and reliability of data and fish survival.

3.7.7.1 Maintenance and Repair

Reclamation will provide the fish agencies notification of salvage disruption (salvage outage) due to planned facility maintenance at least 24 hours in advance. To minimize and avoid salvage disruptions, Reclamation conducts most planned outages during shutdowns of Jones Pumping Plant, typically in the spring and continuing into the summer and fall months. For unplanned facility maintenance, Reclamation will provide notice as soon as practicable and minimize the duration of the salvage outage. Reclamation, through technical assistance with the fishery agencies, will develop an appropriate loss factor for these outages.

Reclamation is required to maintain the Tracy Fish Collection Facility and may not have discretion over when the maintenance must occur.

3.7.8 John E. Skinner Delta Fish Protective Facility

Skinner Fish Facility addresses the entrainment stressor. DWR will operate the facility to screen fish from Banks Pumping Plant. Salvage of fish occurs at the Skinner Fish Facility whenever Banks Pumping Plant is pumping. Fish are salvaged in flow-through holding tanks, monitored by a 30-minute fish count every 120 minutes, and transported by truck to release sites near the confluence of the Sacramento and San Joaquin Rivers. Larval smelt sampling commences upon detection of a spent female at Tracy Fish Collection Facility or Skinner Fish Facility or when a temperature trigger of 53.6°F (12°C) at nearby California Data Exchange Center stations is met. Salvage and operations data necessary to calculate loss are made available daily by 10 a.m. The standard operation procedures for the Skinner Fish Facility are included as Appendix U.

To seek additional improvements to the Skinner Fish Facility; DWR proposes to develop the ALPS-IP. The ALPS-IP would include a structured decision-making (SDM) process to develop and implement a pilot study that would include consideration of additional studies and salvage facility loss parameterization and, potentially, procedural modifications. DWR will proceed with the following items, Debris Management Effectiveness Study, and facility improvements evaluations as described below and on the timelines provided.

3.7.8.1 Maintenance and Repair

DWR will provide Reclamation and the fish agencies notice of salvage disruptions due to planned facility maintenance (planned outages) at least 24 hours in advance. To minimize and avoid salvage disruptions, DWR conducts most planned outages during full shutdowns of Banks

Pumping Plant, frequently in the spring. Further, the modular design of the Skinner Fish Facility in conjunction with total export capacity reductions is used to avoid salvage disruptions for maintenance and repair activities. For unplanned facility maintenance, notice will be provided as soon as practicable. In the event of an unplanned outage (e.g., power disruption) extending beyond one hour, DWR will stop pumping, but may continue to operate the Clifton Court Forebay radial gates.

3.7.8.2 Fish Protection Facility Operations Manual

DWR proposes to develop and implement a revised written training curriculum as identified in section IV: Fish Identification, of the 2021 DWR CDFW Interagency Agreement for Fish Facilities Operation. Additionally, DWR proposes to annually review and update the revised Skinner Fish Facility Operations Manual after WY 2023 as specified in the manual. Skinner Fish Facility will have access to a staff biologist for consultation to support salvage staff, research studies, and special handling of tagged fish.

3.7.8.3 Fish Protection Facility Improvements

DWR proposes to continue to screen fish from Banks Pumping Plant with the Skinner Fish Facility, located west of the CCF, 2 miles upstream of the Banks Pumping Plant. DWR proposes to continue refinement and improvement of the Skinner Fish Facility fish sampling procedures and infrastructure to improve the accuracy and reliability of data and fish survival by:

1. Implementation of the ALPS-IP as part of the Alternative Loss Equation Pilot Study, which would include an SDM process to prioritize potential additional data needs, additional facility improvements to support salvaged listed fish species survival, and more accurate estimates of loss and loss parameters at the SWP and CVP export facilities.

2. Minimization of impacts from debris and excessive numbers of fish, which would include:

a. Continued implementation of the recently adopted fall herbicide application to CCF;

b. An Effectiveness Study to analyze the effectiveness of CCF herbicide application on debris management procedures;

c. If the results of the Effectiveness Study identify feasible additional improvements that require further development and/or prioritization, an SDM process may be utilized to develop improvement requirements including design criteria and/or procedures to implement the study recommendations (e.g. alternative methods of managing fish counts during periods of heavy debris and/or large numbers of fish); and

3. Implementation of updated training curricula as identified in Section 2.3.7.2, “Fish Protection Facility Operations Manual.”

Within one year from the ROD or ITP, whichever is later, DWR will submit a draft Effectiveness Study Plan to agency sub-directors for approval. The Effectiveness Study plan will include a timeline for study completion, and an SDM process for alternatives development and design criteria development with participation from DWR, CDFW, NMFS, and USFWS. At the conclusion of the SDM process, the SDM recommendations will be submitted to the sub-

directors for implementation, as needed. In the interim, the historical count length reduction procedures for managing heavy debris and/or large numbers of fish will be used.

3.7.9 Tidal Habitat Restoration

DWR and Reclamation have or will carry out tidal habitat restoration acre targets identified from the 2008 and 2019 FWS Biological Opinions (8,000 acres) and the 2020 State Incidental Take Permit (396.3) to complete mitigation requirements for delta smelt and longfin smelt (per the 2020 Incidental Take Permit [ITP]). Currently, twelve restoration projects have been identified to satisfy the total acreage requirement of 8,396.3 acres (Table 3-13). The twelve projects are in different phases of completion: 1) constructed (3,584 acres), 2), in construction (3.490 acres) or 3) planned (1,662 acres). All twelve restoration projects are located in the northern arc of the upper estuary (area of highest delta smelt occupation) and are designed to enhance food production and rearing habitat for delta smelt and longfin smelt (per the 2020 ITP). DWR and Reclamation will complete its 8,396.3 acre restoration requirements by 2026.

Table 3-12. Tidal Habitat Restoration

Project	Estimated Acres	Phase
Arnold Slough	138	Constructed
Decker Island	113	Constructed
Lower Yolo Ranch	1713	Constructed
Tule Red	590	Constructed
Winter Island	544	Constructed
Wings Landing	190	Constructed
Yolo Flyway Farms	296	Constructed
Bradmoor Island	490	Under construction
Lookout Slough	3000	Under construction
Prospect Island	1,500	Planning, construction planned in 2024
Chipps Island	687	Planning; construction planned in 2023

The process and documentation for design, protection and long-term management of these sites is described in Appendix V Tidal Habitat Restoration Administrative Process and Documentation Requirements.

3.7.10 Delta Smelt Supplementation

Delta smelt supplementation addresses the Allee effect in the baseline status of wild delta smelt. Too few delta smelt remain for effective breeding in the wild. In water year 2022, the U.C. Davis Fish Conservation and Culture Laboratory (FCCL) raised 55,733 fish that were released into the wild as part of experimental releases. Experimental releases are currently planned through water year 2025. The four years of experimental releases (water years 2022 – 2025) entail experimental learning about the logistics and mechanisms of transport and release, with the intent to inform the design and implementation of supplementation.

USFWS ran a simulation using an updated version of the life cycle model described by Smith et al. (2021) to estimate the probability that different release levels would result in wild Delta smelt populations high enough to support FCCL's broodstock collection efforts. Results indicate that an annual release of 150,000–175,000 fish is needed to have a greater than 50% chance of meeting the collection target. Reclamation and DWR will support a minimum production of 125,000 fish by water year 2024, a minimum of 150,000 fish by water year 2025, and a minimum of 200,000 fish by water year 2026, if feasible, that are at least 200 days post-hatch or equivalent.

Reclamation and DWR, through the Culture and Supplementation of Smelt Steering Committee, will continue to collaborate with USFWS and CDFW on the development of a program to conduct supplementation of the wild Delta smelt population with propagated fish consistent with USFWS' Supplementation Strategy (U.S. Fish and Wildlife Service 2020). The USFWS and CDFW may update the Supplementation Strategy in coordination with Reclamation and DWR. The Supplementation Strategy currently uses the FCCL.

The Supplementation Strategy also identifies a need for additional facilities and evaluation of new approaches to maintain these fish, support supplementation, improve transportation and release of fish, maximize genetic diversity, and minimize domestication effects. An existing Master Plan for a Delta Smelt Conservation Facility Fish Technology Center (U.S. Fish and Wildlife Service 2018) is currently being revisited and further developed to a 35% design-level plan, with completion expected 2024. Additional facilities would require a subsequent set of environmental compliance for their construction and eventual operation. Reclamation and DWR will collaborate with USFWS and CDFW for the additional development of this planning effort, incorporation into the Supplementation Strategy, and the construction and operational needs of facilities capable of meeting production of 400,000–500,000 fish that are at least 200 days post-hatch by water year 2030.

3.7.11 Water Transfers

Water transfers assist California urban areas, agricultural water users, and others in meeting their water needs. Reclamation and DWR will operate the CVP and SWP to facilitate transfers through providing water in streams for delivery to alternative diversion points, conveying water across the Delta for export, or storing water for delivery at a future time.

Seasonal operations describe deliveries up to contract totals. Included in this consultation are transfers of water, up to contract totals, between CVP contractors within counties, watersheds, or other areas of origin (e.g., Accelerated Water Transfers). These transfers do not require demonstration of that water being consumptively used or irretrievably lost to beneficial use.

Transfers not meeting these requirements, including Out of Basin transfers (e.g., Long Term Water Transfer Program (North to South-of-Delta Transfers, Long Term San Joaquin River Exchange Contractor Transfers, "Warren Act Transfers"), follow the *Draft Technical Information for Preparing Water Transfer Proposals, as updated in 2019* (Water Transfers White Paper). The actions taken by contractors to make water available for these transfers (i.e., reducing consumptive use by crop idling, contractor reservoir releases or groundwater substitution) have separate ESA section 7 consultation (see Programs in the Environmental Baseline for additional information), and are not part of this consultation. However, the specific timing and operations associated with the movement of the water to be transferred is a

component of this Proposed Action and, thus, covered by this consultation. Updated in 2019, the paper provides detailed information on establishing transfers and how to complete a particular transfer and document it in a way to prevent harm to other legal users of water. The following is a brief summary from the Water Transfers White Paper on making water available for transfer. Making water available for transfer is not a part of this Proposed Action:

- **Cropland Idling/Crop Shifting Transfers:** Water from idling cropland or growing lower-water-use crops. The seller reduces surface water diversion from their normal operations.
- **Groundwater Substitution Transfers:** Water from reducing surface water diversions and replacing that like amount water with groundwater pumping.
- **Reservoir Storage Release:** Water from seller releasing stored water from their reservoir in excess of what would be released annually under their normal operations (e.g., reservoir storage targets, historical operation patterns, instream flow requirement, conveyance losses, refill, and other downstream obligations).

Reclamation and DWR will provide a transfer window across the Delta from July 1 through November 30. When pumping capacity is needed for CVP or SWP water, Reclamation and DWR may restrict transfers. Maximum transfers are shown in Table 3-14.

Table 3-13. Proposed Annual North to South (out of basin) Water Transfer Volume

Water Year Type	Maximum Transfer Amount North to South (TAF)
Critical	Up to 600
Dry (following critical)	Up to 600
Dry (following dry)	Up to 600
All other years	Up to 360

TAF = thousand acre-feet.

In general, a north to south water transfer involves an agreement between a willing seller and a willing buyer to use available infrastructure capacity to convey water between the parties. To make water available for transfer, the willing seller must take action to reduce the consumptive use of water or release additional water from reservoir storage (i.e., Water Transfers White Paper). This water is then conveyed to the buyers' service area for beneficial use.

Programs to make transfer water available not included in this consultation include:

- Long Term Water Transfer Program (North to South-of-Delta Transfers)
- Long Term San Joaquin River Exchange Contractor Transfers
- Non-Project Transfers, e.g., "Warren Act Transfers"

Reclamation and DWR frequently transfer project and non-project water supplies through CVP and SWP facilities, including in-basin and out of basin transfers. The quantity and timing of a

specific water transfer may or may not require operational changes to both CVP and SWP reservoir releases and CVP and SWP facilities pumping.

3.7.12 Agricultural Barriers

Agricultural barriers maintain water levels for south Delta agricultural diverters. DWR has renewed permits from the USACE for the installation of three agricultural barriers in the south Delta for 2023-2027. DWR may install barriers as early as May 1 in Old River near Tracy 0.5 mile upstream of the Tracy Fish Collection Facility; in Middle River 0.5 mile upstream of the junction with Victoria Canal; and in Grant Line Canal, about 400 feet upstream of the Tracy Boulevard Bridge. All barriers will be removed by November 30 each year.

Operation of the Agricultural Barriers is part of the long-term operation of the CVP and SWP. Upon completion of installation, DWR will allow the barriers to operated tidally depending on stage conditions, except for one culvert at each of the three agricultural barriers. These culverts will remain open beyond June 1 if water levels for diversion in the south Delta is not a concern and the mean daily water temperature at Mossdale is less than 71.6°F (22°C).

3.7.13 Barker Slough Pumping Plant

DWR, at its sole expense, will operate the Barker Slough Pumping Plant to an annual maximum diversion of 125 TAF and a maximum daily diversion rate of 175 cfs. The Barker Slough Pumping Plant is a SWP screened diversion that pumps water through the North Bay Aqueduct, via an underground pipeline, to Cordelia Forebay outside of Vallejo. The North Bay Aqueduct serves Napa County, Vallejo, Benicia, and Travis Air Force Base.

3.7.13.1 Maximum Spring Diversions

DWR operates the Barker Slough Pumping Plant (BSPP) to divert water from the North Delta into the North Bay Aqueduct. Longfin Smelt are attracted to the favorable habitat conditions in the North Delta and can potentially inhabit this area during their spawning period in drier years. The operation of the BSPP in combination with other diversions and losses can result in the net negative flow of water from the North Delta into Barker Slough, and these hydrodynamic conditions can lead to the entrainment of larval Longfin Smelt when they are present. Cumulative BSPP diversions for the January 1 to March 31 period, at design capacity, are limited to approximately 26 TAF. The incidental take of larval Longfin Smelt at the BSPP is expected to be low due to (1) generally minimal diversion rates during periods when larval Longfin Smelt presence is expected to be greatest (February and March) and (2) BSPP utilizing a positive barrier fish screen making the injury or death of adult and juvenile Longfin Smelt unlikely. However, a small number of larval Longfin Smelt may be entrained during BSPP operations when larvae are present in the area.

3.7.13.1.1 Barker Slough Pumping Plant Protections for Larval Delta Smelt

Barker Slough Pumping Plant maximum spring diversions addresses the entrainment risk and transport direction stressor for Delta smelt. Cumulative Barker Slough Pumping Plant diversions for the March to June period, at design capacity, is 42 TAF.

The incidental take of larval Delta smelt at the Barker Slough Pumping Plant is expected to be low due to (1) generally low diversion rates during periods when larval Delta smelt presence is

expected to be greatest (March and April) and (2) Barker Slough Pumping Plant utilizing a positive barrier fish screen making the injury or death of adult and juvenile Delta smelt unlikely. However, a small number of larval Delta smelt may be entrained into Barker Slough during Barker Slough Pumping Plant operations.

3.7.13.1.2 Barker Slough Pumping Plant Conservation Measures

3.7.13.1.2.1Larval Longfin Smelt

DWR proposes to operate the BSPP to protect larval Longfin Smelt from January 1 to March 31 of dry and critical water years. If the water year type changes after January 1 to below normal, above normal, or wet, this action will be no longer in effect. If the water year type changes after January 1 to dry or critical, DWR proposes to operate according to this measure.

From January 1 to March 31 of dry and critical water years, DWR proposes to operate to a maximum seven-day average diversion rate at BSPP less than 100 cfs.

3.7.13.1.2.2Larval Delta Smelt

DWR proposes to operate the BSPP to protect larval Delta Smelt from March 1 to June 30 of dry and critical water years. If the water year type changes after March 1 to below normal, above normal, or wet, this action will be no longer in effect. If the water year type changes after March 1 to dry or critical, DWR proposes to operate according to this measure.

DWR, at its sole expense, from March 1 to April 30 of dry and critical water years, if catch of larval Delta Smelt (length less than 25mm) in 20mm Survey at station 718 exceeds 14% of the total catch of larval Delta Smelt across the North Delta (20mm Survey stations 716, 718, 719, 720, 723, 724, and 726), then DWR proposes to operate to a maximum seven-day average diversion rate at BSPP less than 60 cfs.

DWR, at its sole expense, from May 1 to June 30 of dry and critical water years, if catch of larval Delta Smelt (length less than 25mm) in 20mm Survey at station 716 exceeds 5% of the total catch of larval Delta Smelt across the North Delta (20mm Survey stations 716, 718, 719, 720, 723, 724, and 726), then DWR proposes to operate to a maximum seven-day average diversion rate at BSPP less than 100 cfs.

3.7.13.2 Maintenance

Fish screen cleaning, sediment removal, and aquatic weed removal at the Barker Slough Pumping Plant is needed year-round to maintain operation of the Barker Slough Pumping Plant. Raising and cleaning of the fish screens is necessary to prevent excessive head loss and minimize localized approach velocities.

Sediment removal from the trap and concrete apron in front of the facility is necessary to prevent accumulation and clogging of the screens and facility. Removal of aquatic weeds is necessary to avoid blocking flow and causing water levels to drop in the pump wells behind the screens, triggering automatic shutoffs to protect the pumps from cavitation. Attachment W provides the operating manual and details for Barker Slough Pumping Plant maintenance, including best management practices to minimize adverse effects on listed species.

3.7.14 Clifton Court Forebay Weed Management

Aquatic weed management is needed year-round to prevent potential damage to SWP equipment through cavitation at the pumps and excessive weight on the fish protection louver array. Excessive weed mats entrained into the fish holding tanks and collection baskets in Skinner Fish Facility reduce the efficiency of fish salvage, affect the ability of staff to conduct fish counts, and smother fish. Dense stands of aquatic weeds additionally provide cover for predators that prey on listed species within the Clifton Court Forebay. Algal blooms degrade drinking water quality through production of taste and odor compounds or algal toxins. DWR will apply herbicides and algaecides or will use mechanical harvesters on an as-needed basis to control aquatic weeds and algal blooms in the Clifton Court Forebay. The March 2023 Clifton Court Forebay Aquatic Weed Management Standard Operating Procedures provides the operations manual and details for Clifton Court Forebay Weed Management, including best management practices to minimize adverse effects on listed species.

3.7.15 B.F. Sisk Dam Raise and Reservoir Expansion

Upon completion of construction, Reclamation and DWR will operate Delta facilities with an expanded San Luis Reservoir. The raising of Bernice Frederick Sisk Dam will increase reservoir storage capacity by 130 TAF. Reclamation and DWR completed a final EIS/Environmental Impact Report in September 2019 for the addition of shear keys and downstream stability berms to provide seismic stability for the embankment during a large earthquake and to raise the dam crest by 12 feet. Reclamation consulted with the USFWS on construction and signed a record of Decision in October 2023. This Proposed Action consults on the operational effects from increased exports with an expanded San Luis Reservoir.

3.7.16 Suisun Marsh – Roaring River Distribution System Fall Flood-Up

This Proposed Action includes DWR's operation of the Suisun Marsh Facilities (SMSCG, RRDS, MIDS and GYSO) in accordance with the Suisun Marsh Preservation Agreement (SMPA), which contains provisions for DWR and Reclamation to mitigate the effects on Suisun Marsh channel water salinity from SWP and CVP operations and other upstream diversions. The SMPA requires DWR and Reclamation to meet salinity standards in accordance with D-1641. The SMSCG are operated on an as-needed basis to meet D-1641 and SMPA water quality standards in Montezuma Slough. The duration of gate operation may range from no use to full use for the entire September through May period. Assuming no significant long-term changes in the operational data, gate operations (outside of additional actions described under Delta Smelt Summer-Fall Habitat Action) will continue as necessary to meet D-1641 and SMPA standards.

The Roaring River Distribution System (RRDS) was constructed to provide lower salinity water to approximately 8,000 acres of managed wetlands. RRDS diversion rates have been controlled to maintain a maximum approach velocity of 0.2 feet/second at the intake fish screen except for a 5-week contiguous period (5-week flood-up window) when RRDS diversion rate will be controlled to maintain a maximum approach velocity of 0.7 feet/s for fall flood-up operations. The dates of the 5-week flood-up window may change annually due to waterfowl season dates changing each year and corresponding flood-up needs but will occur during the months of

September through November. The Proposed Action includes operation of the RRDS for a 5-week flood up period each year.

If Reclamation and DWR reinitiate the consultation on the SMP (i.e., *Biological Opinions on the Proposed Suisun Marsh Habitat Management, Preservation, and Restoration Plan and the Project-Level Actions in Solano County, California*), operations of the Suisun Marsh Facilities would be included in their entirety under those consultations and no longer under the long-term operation of the CVP and SWP ROD.

3.8 Stanislaus River

Reclamation operates and maintains the Eastside Division of the CVP for flood control, M&I and agricultural water supplies, hydroelectric power generation, fish and wildlife protection, recreation, and water quality. Reclamation's facilities include the New Melones Dam, Reservoir (2.4 MAF capacity), and Powerplant (Figure 3-7).

The Tri-Dam Project, a partnership between the Oakdale Irrigation District and South San Joaquin Irrigation District, consists of Donnells and Beardsley Dams, located upstream of New Melones Reservoir on the middle fork Stanislaus River, and Tulloch Dam and Powerplant, located approximately six miles downstream of New Melones Dam on the mainstem Stanislaus River. Releases from Donnells and Beardsley Dams affect inflows to New Melones Reservoir. The main water diversion point on the Stanislaus River is Goodwin Dam, an impassable barrier for fish migration approximately two miles downstream of Tulloch Dam.

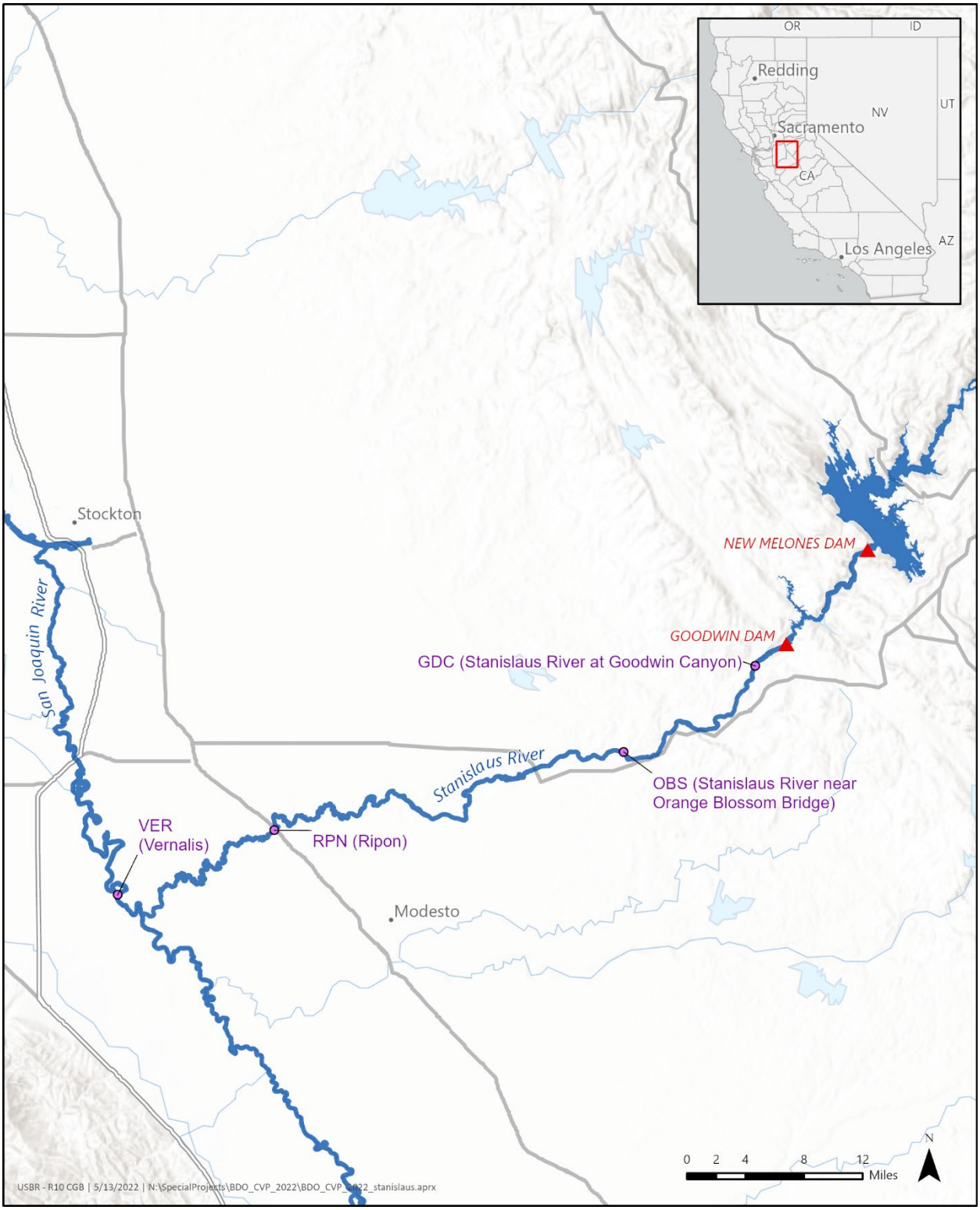


Figure 3-7. Map of the Stanislaus River and Eastside Division

Statutory and Regulatory Requirements, see Appendix A:

- USACE Standard Operation and Maintenance Manual for the Lower San Joaquin River Levees Lower San Joaquin River and Tributaries Project, California (April 1959)
- Public Law 87-874 Flood Control Act of 1962
- USACE Standard Operation and Maintenance Manual for the Lower San Joaquin River Levees Lower San Joaquin River and Tributaries Project, California (April 1959)
- Minimum flow standards below Goodwin Dam: "Interim Instream Flows and Fishery Studies in the Stanislaus River Below New Melones Reservoir" (1987 Agreement between Reclamation and CDFG)
- Minimum Dissolved Oxygen standards: State Water Board D-1422
- State Water Board D-1641, D-1422, D-1616, Bay-Delta Plan flow objectives and subsequent assignment of responsibility
- 1992 CVPIA 3406(b)(2)
- Agreements and Contracts
- 1988 Agreement and Stipulation with Oakdale Irrigation District and South San Joaquin Irrigation District
- Water Service Contracts
- Tri-Dam Agreement

Programs in the environmental baseline to highlight:

- Spawning and Rearing Habitat Restoration
- Temperature Modeling Platform

3.8.1 Seasonal Operations

In the winter and spring, Reclamation will operate to D-1641 and for flood control in accordance with the USACE Standard Operation and Maintenance Manual for the Lower San Joaquin River Levees Lower San Joaquin River and Tributaries Project, California (April 1959). Operating to flood control constraints is relatively infrequent because New Melones is a larger reservoir relative to its annual inflow. However, Tulloch Lake is subject to high local inflows, and may be in flood control operations for brief periods when New Melones Reservoir is not. During these periods, releases from Tulloch Lake may be used to meet flow objectives, schedules, or requirements on the lower Stanislaus River below Goodwin Dam but are generally of a short duration. Reclamation seeks to minimize potential redd dewatering, redd scouring, and juvenile stranding for steelhead.

Reclamation is required to maintain applicable dissolved oxygen standards on the lower Stanislaus River for species protection. The 7.0 milligrams per liter (mg/L) dissolved oxygen requirement at Ripon applies year-round but is most often controlling (requiring additional releases from Goodwin Dam) from June 1 to September 30.

In the fall, Reclamation operates to a D-1641 fall pulse flow requirement at Vernalis in October for fish attraction. Otherwise, Reclamation operates to base flow requirements in order to rebuild storage. If necessary, releases might be made for dissolved oxygen at Ripon or EC concerns at Vernalis, but these are rare.

3.8.2 Ramping Rates

Ramping rates address the stranding risk stressor. Reclamation will coordinate releases on the Stanislaus River as shown in Table 3-15. For determining the water year type, Reclamation will use the San Joaquin Valley "60-20-20" Water Year Hydrologic Classification (60-20-20) developed for D-1641 implementation and based on a 90% exceedance forecast.

Table 3-14. Goodwin Dam Ramping Rates

Goodwin Release Range (cfs)	Standard Rate of Increase (cfs per 2 hours)	Standard Rate of Decrease (cfs per 2 hours)	C and D Water Year Type Rate of Increase (cfs per 2 hours)	C and D Water Year Type Rate of Decrease (cfs per 2 hours)
At or above 4,500	250	250	250	250
2,000 to 4,499	500	250	500	250
500 to 1,999	250	100	500	200
300 to 499	100	50	200	100

cfs = cubic feet per second; C = critical (60-20-20 San Joaquin Index); D = dry (60-20-20 Index).

Reclamation, through the Stanislaus Watershed Team, may develop a faster down ramping rate on a case-by-case basis to implement temporary flow reductions for critical monitoring or maintenance needs. For winter instability flows, Reclamation, through the Stanislaus Watershed Team, may implement faster ramping rates in critical and dry water year types provide more flexibility for shaping flow volumes of water for the purposes of improving biological benefits. Ramping rates that promote recruitment of native riparian vegetation on floodplain surfaces should be considered when instream flow budgets are sufficient. Reclamation may vary from these ramping requirements during flood control.

3.8.3 Minimum Instream Flows

Minimum instream flows (i.e., Goodwin Dam releases) will be in accordance with the 2023 New Melones Stepped Release Plan (2023 SRP; Figure 3-8; Appendix N Attachment N (excel sheet). The 2023 SRP increases the potential outmigration response of juvenile steelhead and increases the annual total volume of water for all year types. Modifications would use a single pulse and increase peak releases from 400 cfs to 3,000 cfs in the default schedule.

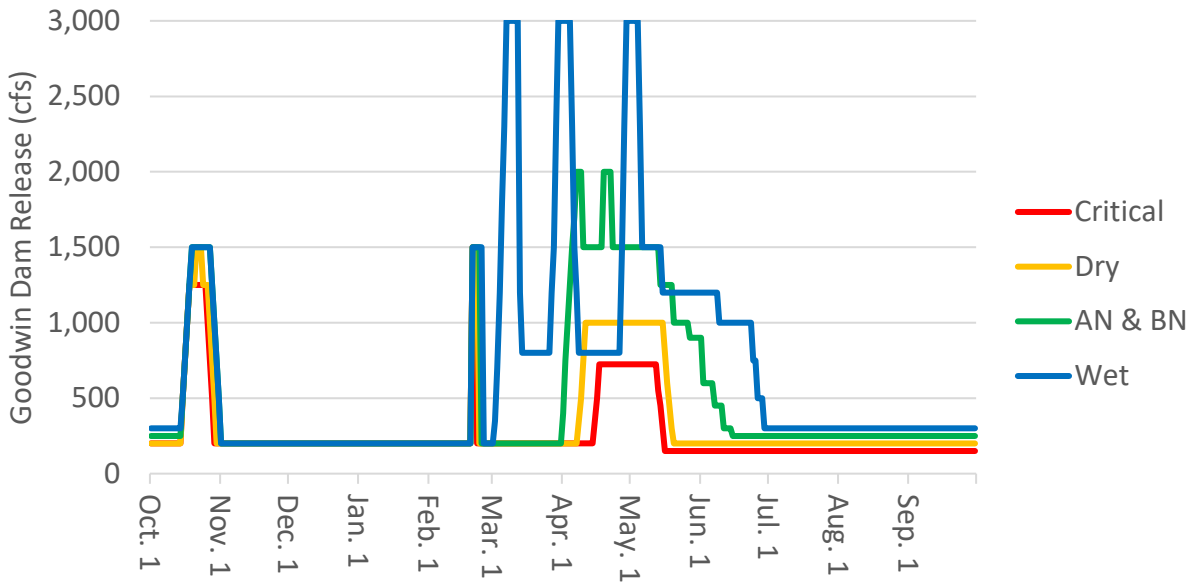


Figure 3-8. 2023 New Melones Stepped Release Plan with Modified Winter Instability Flows

For determining the water year type, Reclamation will use the San Joaquin Valley "60-20-20" Water Year Hydrologic Classification (60-20-20) developed for D-1641 implementation and based on a 90% exceedance forecast. The 2023 SRP includes the ability to shape monthly and seasonal flow volumes as described below:

3.8.3.1 Winter Instability Flows

Winter instability flows address the outmigration and juvenile habitat stressors. Reclamation releases additional flow in February, as provided in the 2023 SRP, to simulate natural variability in the winter hydrograph and to enhance access to varied rearing habitats. Reclamation, through the Stanislaus Watershed Team, schedules the winter instability flow volume. Whenever possible the pulse is scheduled to coincide with a natural storm event, which may naturally cue outmigration. In some years, natural rain events may provide sufficient natural variability in the hydrograph and an additional pulse may be determined to necessary. Reclamation, through the Stanislaus Watershed Team, will prepare an assessment when rain events meet the need for winter instability flows and not require additional releases.

3.8.3.2 Spring Pulse Flows

Spring pulse flows address the outmigration and juvenile habitat stressors. Reclamation will release additional flows starting as early as March through as late as June. Reclamation, through the Stanislaus Watershed Team, will schedule spring pulse flow volumes consistent with volumes in the Stepped Release Plan.

3.8.3.3 Fall Pulse Flows

Fall pulse flows improve instream conditions and provide an attraction cue for adult salmonids returning to spawn. Reclamation will release additional flows in October and/or November. Reclamation, through the Stanislaus Watershed Team, will schedule fall pulse flow volumes consistent with the volumes in the Stepped Release Plan and considering other system objectives.

3.9 San Joaquin River

Reclamation operates the Friant Division for flood control, M&I and agricultural water supplies, and fish and wildlife purposes. Friant Dam provides flood control on the San Joaquin River, downstream releases to meet senior water rights requirements above Gravelly Ford, Restoration Flows under Title X of Public Law 111-11, and diversions into the Madera and Friant-Kern Canals.

The Friant Division facilities include Friant Dam, Millerton Reservoir, and the Friant-Kern and Madera Canals (Figure 3-9). Water is delivered to about one million acres of agricultural land in Fresno, Kern, Madera, and Tulare Counties in the San Joaquin Valley via the Friant-Kern Canal south into Tulare Lake Basin and via the Madera Canal north to Madera and Chowchilla Irrigation Districts.

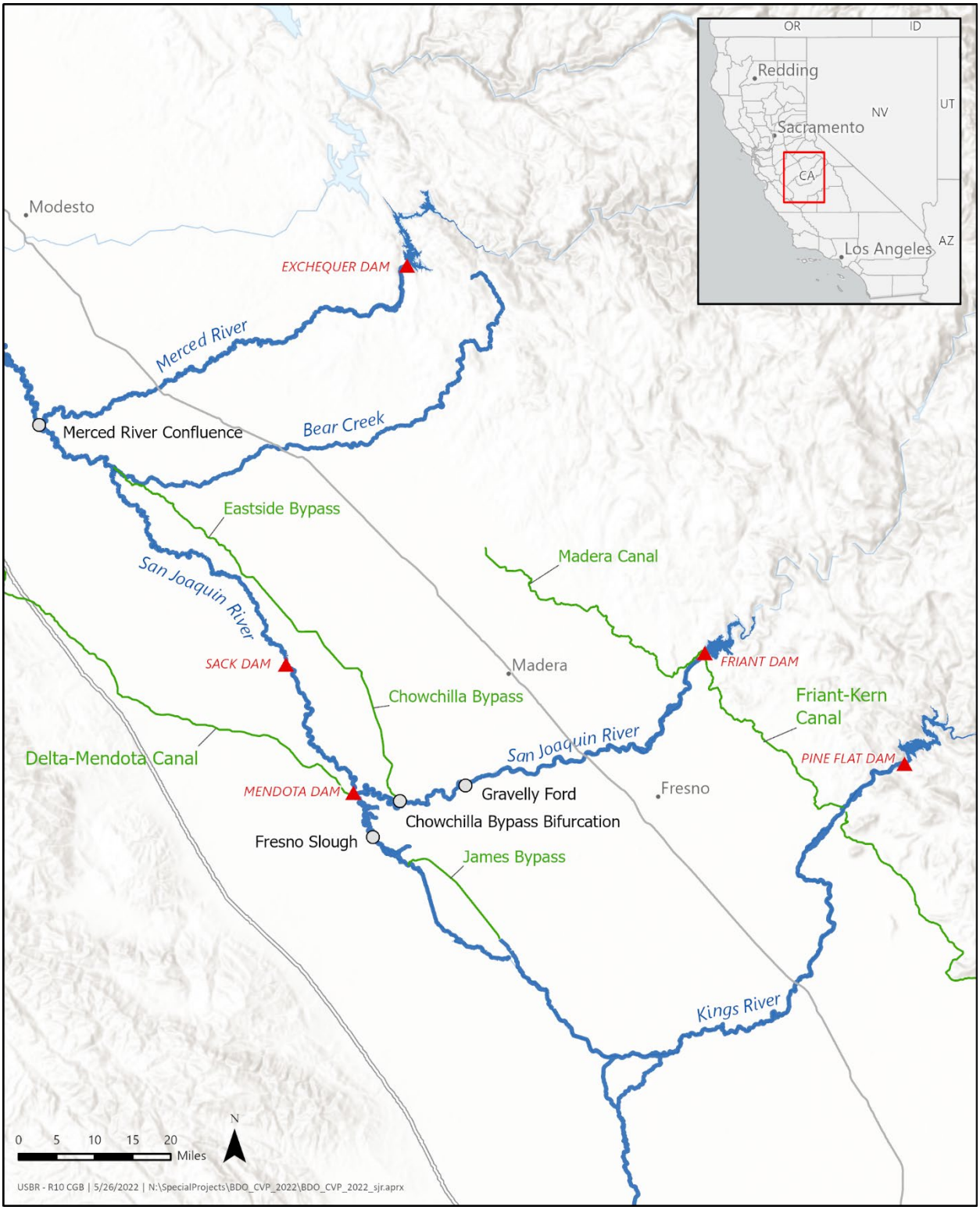


Figure 3-9. Map of the Friant Division and San Joaquin River

Statutory, Regulatory, and Contractual Requirements

- Public Law 74-392 CVP Re-Authorization Act
- Public Law 111-11 (San Joaquin River Restoration Settlement Act)
- State Water Board D-1641
- 1995 Bay-Delta Water Quality Control Plan
- USACE Public Notice 5820A Amended
- Friant Division Riparian Holding Contracts
- Friant Division Water Service Contracts

Programs in the environmental baseline to highlight

- San Joaquin River Restoration Program

Reclamation would operate the Friant Division consistent with the San Joaquin River Restoration Program Record of Decision, which is a related action not included in this consultation.

3.10 Monitoring

Reclamation and DWR would undertake monitoring to inform long-term operations associated with this Proposed Action. Monitoring is necessary to determine and help avoid and minimize the effects of the Proposed Action, including minimizing anticipated incidental take, and informing specific real-time actions.

Because of the ongoing nature of the Proposed Action, ongoing monitoring efforts to inform operational actions and effects of those actions are currently occurring under existing and separate Section 7 consultations and section 10(a)(1)(A) permits and are described in the Baseline. Potential future changes to monitoring programs associated with the operation of the CVP and SWP will be addressed as a Framework Programmatic consultation.

Some programs in the environmental baseline currently provide incidental take coverage for monitoring associated with the Coordinated Operation of the CVP and SWP. Active ESA-listed species take permits and consultations cover real-time monitoring surveys, status and trend surveys, and current special studies. Please refer to Section [TBD] of Chapter 2, *Environmental Baseline*, for more detail on these ongoing monitoring efforts, including regulatory mechanisms that are in place to exempt take from these efforts.

Reclamation and DWR propose a Framework Programmatic consultation approach to include as part of this Proposed Action that addresses future changes to monitoring associated with the Proposed Action. Subsequent changes to existing monitoring programs would be coordinated and included in future consultations of the long-term operation of the CVP and SWP to allow for a more uniform analysis and improved accounting of incidental take coverage associated with the operation of the CVP and SWP. The Framework Programmatic consultation approach specifies that material changes to monitoring efforts and/or ESA compliance would require subsequent consultation.

Reclamation and DWR provide funding to various partners for ongoing monitoring efforts associated with the long-term operation of the CVP and SWP. Section 7 compliance and incidental take coverage would continue to be provided by the existing consultations and permits outlined in the environmental baseline section until and if Reclamation and DWR complete a subsequent consultation with FWS and NMFS on changes to monitoring. Changes outside the scope and effects in the existing consultations and permits are not authorized to commence until the subsequent consultation is completed.

The Framework Programmatic consultation approach for monitoring includes the following principles which would be incorporated into any future changes to monitoring programs addressed in a subsequent consultation:

- Ensure monitoring will be beneficial to long-term operation of the CVP and SWP for:
    - minimizing effects on listed species and habitat (informing real-time operations, understanding species status, etc.)
    - understanding if various operational objectives are met (e.g., effectiveness and validation monitoring); and
    - measuring if and when the reinitiation trigger associated with amount or extent of incidental take has been met.
- Confirm that data collected should meet data quality objectives and open data practices;
- Establish multi-agency collaborative approach including management structure for decision making;
- Ensure scientific rigor of new or modified monitoring and achieving objectives of new or modified monitoring;
- Develop and test mechanisms for learning and adopting new technologies, while maintaining comparability and continuity to historical information on fish and the environment;
- Incorporate a fish, aquatic habitat, and ecosystem monitoring enterprise for the long-term operations of the CVP and SWP should effectively measure physical conditions, water quality, primary and secondary production; abundance, distribution, and production of ESA-listed species (natural and hatchery origin); Delta and tributary fish assemblages; and salvage at the CVP/SWP fish collection facilities;
- Establish mechanisms for close coordination with any existing or future adaptive management program; and
- Provide for robust synthesis of monitoring data to incorporate results and lessons learned.

Monitoring of the LTO operations is subject to change over time by implementing these principles to improve monitoring where incorporating the best available scientific information indicates such change is appropriate. If and when Reclamation and DWR decide changes to a given monitoring program is necessary, Reclamation will provide the supporting information to USFWS and NMFS to support subsequent section 7 consultation as outlined in 50 CFR 402.14.

3.11 Special Studies

Special studies address areas of scientific uncertainty on the reasonable balance among competing demands for water, including the requirements of fish and wildlife, M&I, agricultural, and power contractors. While special studies do not avoid, minimize, or mitigate adverse effects on federally listed species, over time they may inform the effectiveness of measures taken to avoid, minimize, or mitigate incidental take. Studies are incorporated for the following reasons:

1. The study design is complete, implementation is needed to authorize the LTO, and success is not reliant on requiring flexibility to make future changes.

2. Incidental take is likely required: This consultation seeks the necessary incidental take coverage, if not already covered.

3. The new information may reveal effects and/or warrant a modification of the Proposed Action in a manner or to an extent not previously considered: Analysis could consider a broader potential range of operations and/or different confidence in likelihood of effects from operations.

The criteria for identification of a special study in the Proposed Action balances uncertainty and flexibility. Reclamation would not rely on uncertain outcomes from a study but may require direct or incidental take to conduct the study. Requiring modifications to this Proposed Action to change special studies may impose unnecessary administrative delays or risk an unnecessary need for reinitiation of consultation.

Special studies in the Proposed Action are described below.

3.11.1 Steelhead Juvenile Production Estimate

Reclamation and DWR will propose an expanded steelhead JPE framework for the San Joaquin and Sacramento River Basins. Based on data generated from the San Joaquin and Sacramento River Basins, JPE, and feedback from an independent review of progress after 2025, Reclamation and DWR will update the JPE framework including steelhead telemetry, steelhead lifecycle monitoring, and a steelhead JPE.

3.11.1.1 Steelhead Telemetry Research:

Reclamation and DWR will implement Steelhead telemetry research on routing and survival of hatchery- and wild-origin steelhead through the San Francisco Bay-Delta. This research will provide information on how CVP and SWP operations impact steelhead routing and survival through different routes, the facilities, and to Chipps Island. In addition, the steelhead telemetry research may enable through Delta survival estimates for juvenile steelhead tagged in the Stanislaus River or Clear Creek as part of the life cycle monitoring and JPE development in these tributaries.

3.11.1.2 Steelhead Lifecycle Monitoring

Reclamation will maintain the infrastructure supporting the Stanislaus River steelhead life cycle monitoring program and develop infrastructure that will support a life cycle monitoring program in Clear Creek. In addition, Reclamation and DWR will support genetic and age-structure monitoring of juvenile steelhead collected at state and federal salvage facilities to facilitate identification of brood year and natal origin. The goal of this research and monitoring in the San Joaquin and Sacramento Rivers is to provide the data necessary to develop a basin-specific steelhead JPE. In addition, the goal of this research and monitoring is to provide the basis for evaluating how actions related to stream flow enhancement, habitat restoration, and/or water export restrictions affect biological outcomes including juvenile and adult population abundance, age structure, growth and smoltification rates, and anadromy and adaptive potential in Sacramento- and San Joaquin-origin steelhead.

3.11.1.3 Steelhead JPE

Reclamation proposes to develop a steelhead JPE for tributaries with CVP facilities that will focus on the annual production of outmigrating juvenile steelhead. Data used in the JPE will inform the status and trends of Sacramento and San Joaquin basin steelhead and may also help inform actions that will increase steelhead abundance and improve steelhead survival through the Delta. Reclamation and DWR, in coordination with FWS, NMFS, and CDFW, will create or use an existing technical team to use the Southern Sierra Nevada Diversity Group Steelhead Science Plan, which describes the JPE framework, to identify infrastructure and monitoring needs in tributaries with CVP or SWP facilities and a method for expanding the JPE framework from the tributary to basin levels.

Reclamation and DWR propose to conduct the first independent panel review from data generated from the Stanislaus River steelhead life-cycle monitoring program. Reclamation and DWR anticipate the independent panel will provide feedback on the scientific merits of the JPE framework and recommendations for improving the JPE framework. Reclamation and DWR will work with the technical team to incorporate review panel feedback and recommendations on the JPE framework, as appropriate.

Beginning Fall 2025, Reclamation and DWR will work with the technical team to consider implementing an expanded JPE framework to the San Joaquin and Sacramento basins. By summer 2026, Reclamation and DWR will decide to address deficiencies in the JPE framework and/or expand the JPE framework to remaining CVP or SWP tributaries.

Reclamation and DWR anticipate conducting the second independent panel review from data generated from the San Joaquin and Sacramento basins JPE. Reclamation and DWR anticipate the independent panel will provide further feedback on the scientific merits of the JPE framework and further recommendations for improving the JPE framework. Reclamation and DWR will work with the technical team to incorporate review panel feedback and recommendations on the JPE framework, as appropriate.

3.11.2 Spring-Run Juvenile Production Estimate and Life Cycle Model

3.11.2.1 Spring-run Chinook salmon Juvenile Production Estimate (SR-JPE)

Reclamation and DWR will support continued development of a SR-JPE framework for CVP and SWP tributaries and the Delta, and propose a framework for implementation, including an approach for modeling a SR-JPE and the monitoring program to support that approach. The SR-JPE framework will incorporate independent review and will be the basis for consideration of updated entrainment minimization measures, including updating hatchery surrogate measures. The process to develop the framework will continue the ongoing effort to develop a SR-JPE initiated in 2020 and outlined in the SR-JPE Science Plan (California Department of Water Resources et al. 2020), the SR-JPE Interim Monitoring Plan (Allison et al. 2021), the SR-JPE Run Identification Research and Initial Monitoring Plan (Bedwell et al. 2021), the SR-JPE Data Management Strategy (Harvey et al. 2022), and the SR-JPE Decision Charter (Horndeski 2022). These plans describe the decision processes, research, monitoring, and data management infrastructure that will be needed to meet the goal of developing an SR-JPE ready for implementation in 2026, including guidance by an interagency Core Team using structured decision making principles, rapid and coordinated reporting of new data onto a publicly accessible repository, routine and rapid genetic testing, and additions to existing and/or new monitoring programs at Delta entry and in representative spring-run streams: Clear Creek, Battle Creek, Mill Creek, Deer Creek, Butte Creek, Yuba River, and Feather River.

3.11.2.2 Spring-run Chinook Salmon Lifecycle Model

DWR and Reclamation will support the development of a Spring-run Chinook Salmon Lifecycle Model (SR-LCM) for the purpose of informing management actions to improve Central Valley spring-run population status. DWR and Reclamation will assemble an interagency management team including representatives from Reclamation, DWR, CDFW, NMFS, and USFWS, to define the specific management issues and objectives to be addressed by the SR-LCM. Because of the close link between SR-LCM and SR-JPE development through a shared use of historical and newly generated data, the SR-JPE Core Team will be responsible for guiding the development of the SR-LCM to address the management objectives, and for determining whether the required modeling can be accomplished through an update of one or more existing Central Valley (CV) Chinook salmon modeling efforts, such as the SR-JPE, the NMFS spring-run lifecycle model, and the CVPIA Science Integration Team salmon lifecycle models. The Core Team will use structured decision making principles when appropriate. The Core Team will develop and submit a modeling plan and timeline to the SR-LCM management team for approval, and guide implementation of the plan. To facilitate open communication between the lead life-cycle modeler and agency staff, a Lifecycle Model Subteam will be established. Throughout the process to develop and implement the SR-LCM, the lead lifecycle modeler will collaborate with the Lifecycle Model Subteam through regular meetings to solicit feedback and integrate that feedback into model development iteratively, in a manner similar to the SR-JPE Modeling Subteam described above.

Required actions in 2025:

1. Under the guidance of the Core Team, the Modeling Team will develop an initial JPE model based on available spring-run data and provide the model to the Core Team for review. The Core Team will recommend an SR-JPE framework, composed of the initial SR-JPE model and the monitoring program required to provide data to calculate an annual JPE.
2. DWR and Reclamation will assemble the SR-LCM Management Team and begin coordination with the SR-JPE Core Team on the development of the SR-LCM.

Required actions in 2026:

1. In coordination with the SR-JPE Core Team, the Adaptive Management Steering Committee will charter and convene an independent peer review panel to provide feedback on the SR-JPE Core Team's recommended SR-JPE framework.
2. Following the independent peer review, DWR and Reclamation will prepare a draft SR-JPE Plan in collaboration with CDFW, NMFS, and USFWS that describes the approach to calculating a SR-JPE and the monitoring and special studies needed to collect the data to calculate a SR- JPE annually. The draft SR-JPE Plan will be guided by the SR-JPE Core Team SDM process and SR-JPE framework recommendation, and by the independent peer review panel. DWR and Reclamation will submit the draft SR-JPE Plan to the SR-JPE Core Team for review and work collaboratively to incorporate SR-JPE Core Team comments into the final SR-JPE Plan.
3. The SR-JPE Core Team will review the spring-run Chinook Salmon hatchery surrogate OMR measure .
4. DWR, CDFW, Reclamation, and NMFS will meet to contemplate development of a new or modified spring-run Chinook Salmon hatchery surrogate OMR measure informed by the independent peer review panel input on the SR-JPE framework, historical spring-run Chinook Salmon data, new data obtained from the monitoring and special studies needed to collect the data to calculate the SR-JPE, SR-JPE Core Team review of the spring-run Chinook Salmon hatchery surrogate OMR measure, and other relevant information (for example Georgiana Slough monitoring data). Any new approach for spring-run Chinook Salmon will:

    a. Take into account the limitations of the initial SR-JPE approach to calculate the SR-JPE

    b. Be an interim approach to be refined as the SR-JPE approach evolves and the SR-LCM is completed

    c. Anticipate future iterations and refinements of SR-JPE approach

    d. Rely primarily on monitoring data rather than salvage data

5. DWR and Reclamation will submit the final SR-JPE Plan to CDFW and NMFS for approval no later than six months after the independent peer review and spring-run

Chinook Salmon hatchery surrogate OMR measure review are completed, whichever is later.

5. After the final SR-JPE Plan is approved by CDFW and NMFS, DWR and Reclamation will convene the SR-JPE Core Team and subteams to provide an annual SR-JPE estimate, implement the final SR-JPE Plan (including monitoring), and ensure all data obtained through long-term monitoring programs is stored in a publicly accessible repository.
6. The SR-JPE Core Team will develop and submit a draft SR-LCM Modeling Plan and timeline to the SR-LCM Management Team for approval and guide implementation of the final SR-LCM Modeling Plan upon approval.
7. DWR and Reclamation will assemble the Lifecycle Modeling Subteam for coordination between the lead life cycle modeler and the SR-JPE Core Team.

Required actions in 2027:

1. If approved by CDFW and NMFS, DWR and Reclamation will implement the new or modified spring-run Chinook Salmon OMR measure based on the initial SR-JPE approach to calculate the SR-JPE.
2. DWR and Reclamation will implement changes to monitoring if recommended through the SR-JPE SDM process and approved by CDFW and NMFS, through appropriate take authorization for monitoring activities and contingent on stakeholder participation from non-CVP or SWP tributaries.
3. The SR-JPE Modeling Subteam will continue to develop and refine the SR-JPE model by integrating new data as they become available and adjusting the modeling approach in collaboration with the SR-JPE Core Team and in response to SDM processes conducted by the SR-JPE Core Team.
4. The Lifecycle Modeling Subteam will convene regular meetings to implement the final SR-LCM Modeling Plan and to solicit and incorporate feedback on model development.

Required actions in 2028:

1. Under the guidance of SR-LCM Management Team and SR-JPE Core Team, the Lifecycle Modeling Subteam will recommend an initial SR-LCM.

2. In coordination with the SR-JPE Core Team and the SR-LCM Management Team, the Adaptive Management Steering Committee will consider chartering and convening an independent peer review panel to provide feedback on the SR-JPE model and the initial SR-LCM.

Required actions in 2029 and 2030:

1. Following the independent peer review, the SR-JPE Core Team and the Lifecycle Modeling Subteam will review independent peer review panel input (if convened) and the SR-JPE Core Team will use SDM to evaluate and implement changes to the SR-JPE model and the initial SRLCM.

3.11.3 Tidal Habitat Restoration Effectiveness

DWR and Reclamation will use the adaptive management program to evaluate and identify actions that may improve the effectiveness of its restoration projects. Adaptive management actions will be focused on a comprehensive understanding of how all restoration projects function across the landscape and in consideration of other conservation measures (e.g., Yolo Notch Project, etc.). that may enhance food web production and rearing habitat for Delta smelt. The process for completing the administrative documentation to ensure these restoration sites are protected, monitored, and managed so that they function as intended long-term. This process is described in *Appendix V: Tidal Habitat Restoration Administrative Process and Documentation Requirements.*

3.11.4 Tributary Habitat Restoration Effectiveness

The Upper Sacramento River Anadromous Fish Habitat Restoration Project Monitoring Plan and Protocols (2017) are designed to determine the effectiveness of the Upper Sacramento River Anadromous Fish Habitat Restoration Project in meeting identified objectives and to validate the linkage between restoration actions and the biologic response to those actions. This monitoring plan follows the framework for detecting biological responses to flow management described by Souchon et al. (2008). Monitoring methods structured as field protocols are described in the Plan and Protocols including control site selection, longitudinal profile and cross sections, juvenile habitat mapping protocols, snorkel survey protocols, seining, enclosure studies, invertebrate drift sampling, redd surveys, and stream temperatures. The existing CVPIA Upper Sacramento River Habitat Restoration Technical Team includes Reclamation, USFWS, NMFS, CDFW, consultants (e.g., Chico State University, PSMFC), and recipients of competitive funding for habitat restoration will be utilized as the AMT for this action.

3.11.5 Winter-Run Early Life Stage Studies

Sacramento River winter-run Chinook salmon (winter-run) are exposed to a variety of stressors throughout their lifecycle that impair their survival, reproduction, and the ability of the population to rebound from periods of low abundance. Survival during early life stages—spawning success, egg incubation, emergence, and juvenile rearing and migration—is affected by various environmental factors. Understanding the relative contribution of different stressors, particularly those that we can manage through water operations and other actions, will improve our ability to manage water and improve winter-run early life stage survival.

The Early Life Stage Survival Science Action aims to address two distinct knowledge gaps:

1. Reducing uncertainty around the effects of water temperature and other factors (e.g., dissolved oxygen, spawning habitat and flow) on egg-fry-survival
2. Improving understanding of juvenile survival during rearing and migration, including reducing uncertainties in the field monitoring data

3.11.6 Shasta Spring Pulse Studies

Reclamation and DWR, through the SRG, will support hindcast evaluation of action effectiveness that includes technical review of the functional elements of the pulse flow (i.e.,

timing, magnitude, duration, and frequency) as well as an evaluation of criteria used to support beneficial use decisions.

3.11.7 Delta Route Selection and Survival

These studies involve an acoustic receiver network and associated real-time and retrospective modeling of the data. The objectives are to provide real-time estimates of reach-specific survival and route entrainment for juvenile salmonids in the Sacramento River and Delta.

3.11.8 Delta Smelt Summer and Fall Habitat

DWR and Reclamation will consider food subsidy measures to augment the Summer-Fall Habitat Action. Food subsidy actions are hypothesized to increase localized prey availability for delta smelt in the north Delta and Suisun Marsh, resulting in opportunities for higher growth and survival of juvenile and sub-adult life stages. DWR and Reclamation will decide which of the following food subsidy actions are most appropriate given hydrologic conditions (i.e., water year type), logistical constraints, and information needs: one of several variations of the North Delta Food Subsidy Action, one of several variations of Managed Wetland reoperation in Suisun Marsh, and/or the Sacramento Deepwater Ship Channel Food Subsidy Action. For any year when one or more of the food subsidy actions is implemented, an action plan, science and monitoring plan, and monitoring report will be produced to evaluate action effectiveness. Monitoring plans and reports will also be produced in years actions are not implemented to serve as contrasts to baseline conditions. Food subsidy action plans, monitoring plans, and reports will be developed in collaboration with, and reviewed by the DCG. Food subsidy action research results will be included in seasonal reporting and adaptive management reviews of the Summer-Fall Habitat Action to evaluate the science and monitoring, efficacy of actions, hypothetical alternative strategies and/or actions, and potential inclusion of food subsidy actions as potential permanent action elements of the Summer-Fall Habitat Action, or if appropriate, termination of actions deemed ineffective.

3.11.9 Longfin Smelt Science Plan

DWR, in coordination with Reclamation, will implement science activities identified in the 2020 ITP Longfin Smelt Science Plan; including the development of mathematical life cycle model. The life cycle model will be used as a quantitative tool to characterize the effects of abiotic and biotic factors on Longfin Smelt populations. Additional Longfin smelt science and monitoring informed by the life cycle modeling efforts will be implemented as needed through the Adaptive Management process.

3.11.9.1 Longfin Smelt Science and Monitoring Initiatives

DWR and CDFW, in collaboration with the State Water Contractors and USFWS, developed the LFSSP to meet a requirement in the 2020 ITP, and the LFSSP was finalized on December 8, 2020. DWR, in coordination with Reclamation, will support the implementation of the Longfin Smelt Science Plan (LFSSP) through a multi-agency process. The purpose of the LFSSP is to provide a framework for Longfin Smelt science investments through 2030, including seven key priority areas. Longfin Smelt science and monitoring informed by the life cycle modeling efforts will continue beyond 2030, as appropriate.

Science priority areas in the LFSSP:

1. Life cycle modeling
2. Factors affecting abundance, growth, and survival
3. Improved distribution monitoring
4. Improved larval entrainment monitoring
5. Longfin Smelt culture
6. Fish migration and movements
7. Spawning and rearing habitats for Longfin Smelt

The Longfin Smelt Technical Team is charged with the implementation and refinement of the science conducted under the LFSSP. Additionally, the Longfin Smelt life cycle model, prioritized in the LFSSP and currently under development, will highlight critical gaps in our current understanding of Longfin Smelt ecology and will guide implementation of core elements of the LFSSP, particularly with respect to new and expanded monitoring.

3.11.10 Management of Winter-run Spawning Location and Timing

Reclamation will study how flow and temperatures can be used to manage Sacramento River winter-run Chinook salmon spawning on the Sacramento River. Reclamation will support the applicable costs and implement the results of the studies, contingent on available appropriations, to improve future management as applicable. This action does not specify the funding level for this project, only the commitment to fund as appropriations are available. The goal of this management action is to ensure a resilient portfolio of life history strategies by supporting a diversity of spawn timings and locations in the population.

Modeling indicates that the peak spawn timing of winter-run Chinook salmon may be influenced by water management decisions that are intended to conserve cold water for use during the summer temperature management season (Johnson et al. 2017; Windell et al. 2017). Annually, the start timing of winter-run Chinook salmon spawning is relatively constant while the peak varies year to year – with cool springtime water temperatures associated with earlier peak spawning, and warm springtime temperatures associated with later peak spawning (Hendrix et al. 2017, Jennings and Hendrix 2020). Specifically, there is evidence that higher April and May water temperatures correspond to increased and delayed peak spawning in July and August. The model using both April and May temperatures as cofactors had the best fit to the observed female spawner data (Jennings and Hendrix 2020). In their historic spring-fed stream habitat, cool spring temperatures are hypothesized to trigger earlier peak in spawning to ensure sufficient time for egg maturation. Conversely, historically (pre-dam), later peak spawning in warm years could have resulted in later peak emergence; this could mean the juvenile fish experienced lower temperatures upon emergence reducing egg and alevin mortality.

However, a cause-and-effect relationship between water temperatures during pre-spawn staging and the timing of peak spawning has not been demonstrated. Randomized experimentation should be used to determine whether manageable changes in water temperatures during the period of pre-spawn staging directly cause changes in the spawn timing of winter-run Chinook salmon and, if so, the level of covariation between these variables. Findings from these

investigations may explain a direct linkage between temperature management and winter-run Chinook salmon reproductive performance on the Upper Sacramento River (National Marine Fisheries Service 2014, Bureau of Reclamation 2019), as evidence suggests reproductive success is variable (Blankenship et al. 2020). In light of this potential relationship, two possible management strategies are suggested by Jennings and Hendrix (2020):

To mitigate winter-run Chinook Salmon egg and alevin mortality during drought years, two possible strategies for cool water management are: (1) release cool water early (April-May) to drive the peak of winter-run spawning earlier in an attempt to achieve emergence from gravel before temperatures increase; or (2) hold cool water until later in the season, when the bulk of spawners begin to deposit eggs… ultimately, models that combine reservoir management dynamics with winter-run Chinook salmon spawning and egg incubation will be necessary to understand how reservoir management might affect spawn timing, egg and alevin development, and egg-to-fry survival under various climate conditions.

This research strategy recommends a phased approach to better understanding the relationship between water temperatures during winter-run Chinook salmon staging and the timing of peak spawning.

1. Implement necessary studies to determine whether a functional (cause and effect) relationship exists and what is the nature and strength (variability) of that relationship.
2. Develop analytical tools to evaluate potential management opportunities that could use the functional relationship (if it exists) to benefit the reproductive success of winter-run Chinook salmon. This phase of the investigation may involve assessments of the interaction between multiple life stages runs, and species with different water operation scenarios. For example, early warm water could also affect *O. mykiss* egg survival or influence the distribution of spring run Chinook Salmon by altering the river's temperature relative to that of Clear Creek.

The first phase of the research strategy could include a literature review or analysis of temperature data and information to assess effects on Chinook Salmon migration timing. Another initial step could include manipulative, randomized experimentation to evaluate the relationship between water temps during adult staging and spawn timing. Such a study's objective would be to demonstrate a cause-and-effect relationship through a controlled, manipulative experimentation in a captive environment, such as a hatchery, where individual fish can be randomly assigned to treatment groups consisting of different water temperatures.

The second strategy was implemented in the river in 2021 when we bypassed power production to release warmer water in April and May, saving the cooler water till later in the season. The effectiveness of this action can still be evaluated using the data collected over that season.

Modeling will be an important tool for the second phase of the proposed research strategy. Modeling operational scenarios will help plan the action by estimating the potential effect(s) of operational actions on smolts survival across different hydrological conditions. Modeling will also be used to evaluate any potential increases to winter-run Chinook Salmon TDM and estimate potential decreases in the Shasta Reservoir Cold Water Pool as a result of different

operational actions. The modeling may also consider possible impacts to pre-spawn mortality from running warmer earlier in the season. An evaluation of the modelling tools will be assessed by comparing predictions with monitoring data which will be documented in Reclamation's Shasta Cold Water Pool Seasonal Report and/or Shasta Storage Rebuilding Seasonal Report.

During the second phase of the research strategy, hypothetical tradeoff scenarios may include preserving cold water until peak spawning and emergence occurs to reduce TDM impacts to early life stages. At certain warm temperatures, pre-spawn mortality may occur.

Annually, real-time operations monitoring will be implemented to measure biological and operational responses relevant to evaluating the relationship between spring water temperatures and spawning timing and location. These include spawning timing, spawner condition, redd location, water temperatures, and egg-to-fry survival.

Reports as part of this multiyear Research Strategy will communicate the operational effects of the water and temperature management actions taken for managing winter-run Chinook salmon spawning and other observed biological and ecological responses. Modeling and decision support tools can highlight the magnitude of uncertainty related to mechanisms behind spawn timing that may warrant experiments to better understand the potential impacts of managing spawning behavior.

The primary objective of these activities will determine if keeping water colder earlier induces earlier spawning, or if keeping April/May Sacramento River temperatures warmer induces later spawning. It would be valuable to be able to identify and quantify if spawning timing contributes to or limits reproductive success to better assess proportional sources of mortality by separating pre-spawning water temperature effects from other variables (e.g., thiamine deficiency, incubation temperatures, redd superimposition, habitat restoration, water quality, hatchery effects, etc.). The research strategy may support learning about reproductive success, more broadly, as an additional objective.

No later than one year after completion of consultation, Reclamation will submit to NMFS for approval a report that identifies technical team membership, provide a final list of study topics and alternatives for agency management review, and committed funding levels, contingent on available appropriations, to implement the action. When research actions are completed, Reclamation will report the result to the Sacramento River Temperature Task Group for potential implementation into temperature management.

Potential research actions may include:

- Summarize available literature on thermal tolerance for adult Sacramento River Winter-Run Chinook to understand drivers of spawning behavior, gamete viability, epigenetics, and prespawning stress/mortality.
- Controlled experimentation (e.g., in a laboratory or hatchery setting) to evaluate effects of water temperatures on spawning timing of winter-run Chinook salmon.
- Review available data and/or measure historic Shasta spring operations effects of temperatures on adult Chinook salmon (e.g., pre-spawning stress/mortality, changes in

spatial and temporal spawning distribution). May include acoustic telemetry study of adult behavior or observations from carcass survey. " Analyze spawn timing has shifted in the past 20 or so years and how that relates to flows before and during spawning to determine if management recently has shifted spawning behavior.

- Calculate Sacramento River winter-Run Chinook salmon birth date distributions, which could be accomplished by otolith analyses of juvenile Chinook salmon collected at Red Bluff Diversion Dam (RBDD). This would provide information on whether there was disproportionate survival of progeny from the temporal distribution of adult spawners (e.g., early vs. late spawning). Genetic method could also help test for disproportionate survival of progeny from early vs late spawning females.
- Genetic analyses (i.e., parentage and relatedness approaches of adults and juveniles) to see which juveniles survive from which spawning adults (specifically associated with spawning location, time, sex, and origin).
- Reconstruction of temperature histories of juveniles at RBDD or returning adults to assess the temperatures individuals experienced at emergence. Oxygen isotope measurements in otoliths can provide this temperature reconstruction. Paired with thermal landscapes, one can assess mortality (lack of representation) of individuals sampled at a later point in time.

Previous efforts for this action are described in the Spring Management of Spawning Locations Research Strategy.

3.11.11 Alternative Loss Estimation Pilot Study

DWR, in coordination with Reclamation, has completed a draft updated Alternative Loss Equation (ALE-22) software tool for estimating losses at the SWP and CVP export facilities to quantify incidental take of winter-run and spring-run Chinook Salmon, and Central Valley (CV) steelhead. DWR, in coordination with Reclamation, proposes to further refine the parameters of this tool by developing an ALPS-IP to implement this tool in parallel with current loss estimation methods. The goal of this pilot study is to provide a more accurate estimates of loss, and loss parameters, at the SWP and CVP export facilities while understanding the utility of the new alternative method relative to the existing method. The ALPS-IP will be completed in coordination with the Skinner Fish Facility and Salvage Release sites improvements activities and if practicable will be utilized to further enhance these activities.

DWR and Reclamation propose to collaborate on the following actions:

1. ALPS-IP Development

- Within six months of the latest effective date of the ROD or ITP, DWR in collaboration with Reclamation shall conduct a knowledge transfer and methods workshop for the ALE-22 tool. Participants may include representatives from NMFS, USFWS, CDFW, DWR, State and Central Valley Water Contractors, and Reclamation.
- Within six months of the completed ALE-22 workshop DWR, in collaboration with Reclamation, shall convene the ALE Technical Team (ALE-TT), a sub-team of the

Central Valley Fish Facilities Review Team (CVFFRT), and DWR shall submit a draft ALPS-IP to the ALE-TT for review and comment.

- The draft ALPS-IP shall include:
    - SDM process outline
    - Interim, draft, and final reporting protocols
    - Pilot Study design
    - Procedures, and timelines (e.g., start and stop dates)
    - Target species (e.g., winter-run and spring-run Chinook Salmon, and California CV steelhead)
    - Assessment of multiple parameters to account for losses including, but not limited to salvage facility outages during louver cleaning or mechanical failure; post release survival on salvaged fish

- Within four months of receiving ALE-TT review comments DWR would submit the final draft ALPS-IP to the CVFFRT, SaMT, and the agency sub-directors for comment/approval.
- Within one month of receiving CVFFRT, SaMT review, and subsequent agency sub-director comments/approval DWR would finalize the ALPS-IP.

2. Pilot Study Implementation and Prioritization

- DWR and Reclamation shall conduct the ALPS-IP pilot study as defined.
- DWR and Reclamation would utilize the ALE-TT and the defined SDM procedures to complete a prioritization of the pilot study recommendations for further implementation.
    - The ALE-TT may utilize an independent science panel review to further enhance the SDM prioritization process.
- DWR and Reclamation shall complete the Pilot Study and prioritized recommendations within 1.5 years of completing the ALPS-IP and submit final recommendations to the agency sub-directors for approval.

3. Implementation Prioritization recommendations

- DWR and Reclamation shall proceed with the recommendations for further implementation

The ALPS-IP, Pilot Study, the prioritization of the recommendations for further implementation, and implementation shall be completed within 7 years after the latest effective date of the ROD or ITP.

3.11.12 Georgiana Slough Migratory Barrier Effectiveness

Operation of the salmonid migratory barrier should improve the seasonally averaged through-Delta survival probability to Chipps Island compared with survival probability if the salmonid barrier were not in operation. Barrier operations and monitoring details are defined in the Georgiana Slough Salmonid Migratory Barrier (GSSMB) Operations and Monitoring Plans developed by the GSSMB Coordination Group. To further maximize seasonal survival benefits to migrating salmonids, DWR and Reclamation will continue leading the GSSMB Coordination Group, with membership comprised of DWR, Reclamation, CDFW, USFWS, NMFS, and State/Federal Water Contractors representatives. DWR and Reclamation, working with the GSSMB Coordination Group, will provide at least a triennial report and review and update, as necessary, the GSSMB Operations and Monitoring Plans.

3.12 Drought

Starting each October, Reclamation and DWR, through the Drought Relief Year Team, will meet at least monthly to determine whether it would be appropriate to pursue actions to respond to current or anticipated drought and dry year conditions. At each meeting, Reclamation and DWR will review the actions in the Drought Toolkit, Appendix Q and determine if it would be appropriate to pursue any of them, and evaluate the effectiveness of those actions. The Drought Toolkit will list the minimum decisions required each month and Reclamation and DWR expect a more focused review of the Drought Toolkit in times when resources to meet required operations and goals are limited. These limited resources may include, but are not limited to hydrology, current and projected reservoir storages, facility limitations and fish conditions. These decisions will be documented monthly or more often if necessary in the WOMT notes.

Reclamation and DWR, through the DRY Team, may update the Drought Toolkit. Reclamation and DWR, through the DRY Team, will evaluate drought actions taken to reduce drought impacts related to CVP and SWP operations described in the Drought Toolkit. This evaluation will provide additional information on the effectiveness of drought response so as to support updates to the Drought Toolkit. This evaluation will be included in the annual Drought Report.

3.13 Governance

3.13.1 CVP/SWP Governance

CVP/SWP Governance identifies ongoing engagement by participating State and Federal Agencies (collectively the “Agencies”), interested parties, and/or the public following completion of the Biological Opinions and Record of Decision. Governance describes the system-wide organization of technical groups, group membership, activities that are subject to governance, and decision making approaches and protocols.

The purposes of CVP/SWP Governance are to:

- Identify the roles and responsibilities of the agencies that are part of real time operations

- Establish that the agencies will work together in good faith
- Identify the governance principles agreed to by the participating agencies
- Identify operations that are subject to Governance
- Identify the implementation teams that are part of governance, and processes for technical collaboration and elevating issues for resolution
- Incorporate learning and adopt new technologies from monitoring, adaptive management and ongoing science
- Describe relationships between technical and policy groups
- Describe Reporting and Outreach

The Agencies are committed to communicate each organization's respective interests and recognize the intent to work together in a good faith effort to resolve issues through the groups described in this governance document. Every member is committed to identifying potential issues and communicating these issues to the relevant technical or policy team as soon as possible. Representatives who participate on technical and policy teams are clear about their ability to represent agency decisions. Representatives who participated on technical and policy teams are empowered to represent their agency and make decisions appropriate for that level. Each representative represents the science, policy and management based on the best of their ability and current knowledge. Representatives come understanding their authority (not agency authority but representatives' authority). Representatives are aware and clear about their role with other members. Representatives will either be able to make decisions on other parts of the system or have an avenue for doing that quickly.

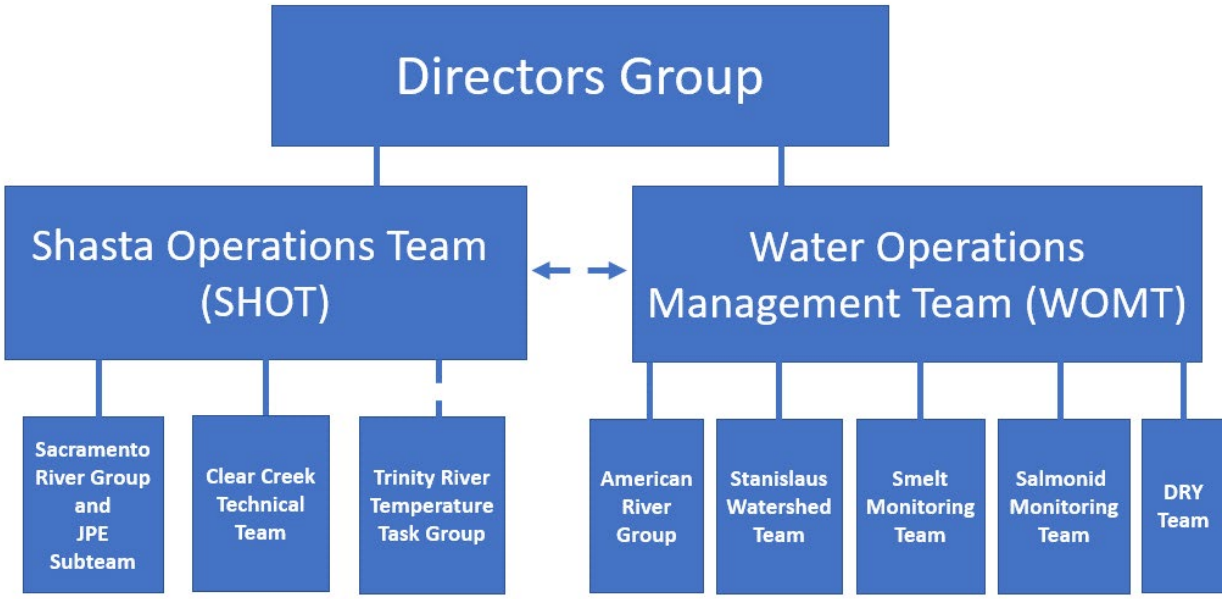
CVP/SWP Governance is framed around the following principles:

- **Collaboration—**The leading principle of CVP/SWP Governance is collaborative, science-based decision making. CVP/SWP governance is structured to seek consensus across scientific, technical and policy levels, with elevation and decision making processes in place when consensus cannot be reached.
- **Effectiveness—**It is workable and efficient. Effectiveness considers what information is available and when. Effective CVP/SWP governance recognizes that there is more uncertainty early in the year and that uncertainty may change as the year progresses.
- **Accountability—**Operational, regulatory, proactive, and addresses long-term planning.
- **Inclusiveness—**Collaborative and cooperative. The elevation and decision making structure maintains accountability at all levels.
- **Transparency—**The processes are not ambiguous. They are open for others to see and understand through implementation of a communication plan.
- **Communication—**Be aware and clear about roles. If you spot a potential issue, communicate it.

3.13.2 Organizational Structure and Description of Collaborative Teams by Division

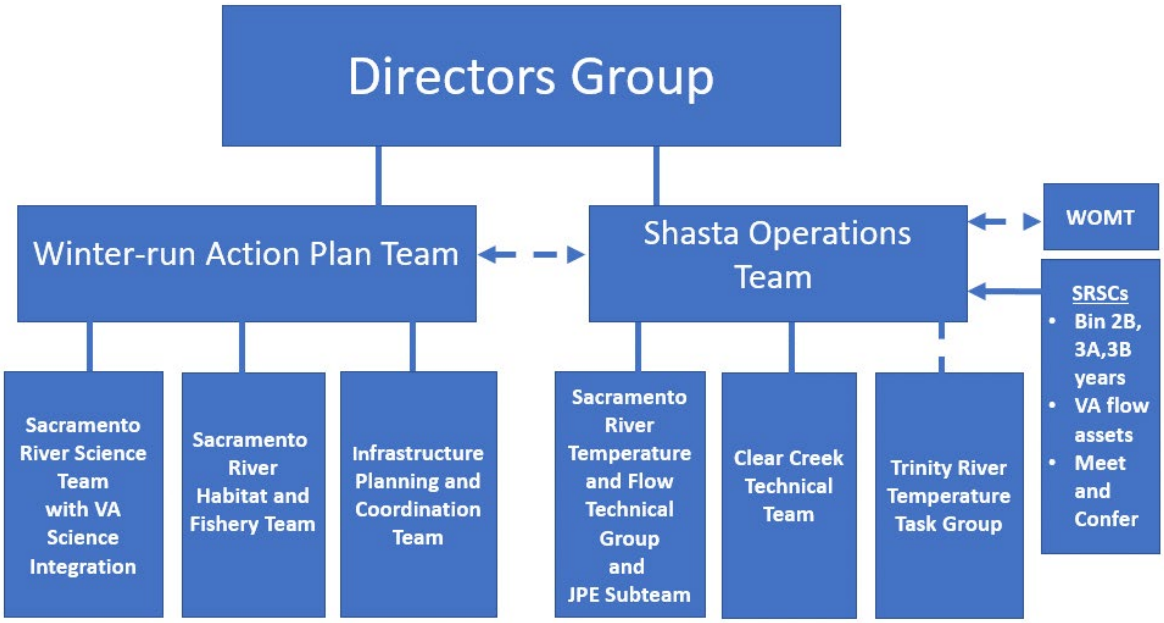
CVP/SWP Governance is structured such that a 5 Agency Directors Group oversees the ongoing authorities of each respective agency and serves as the final decision making body for operational matters. The Directors Group directly interfaces with two management and policy level groups (SHOT and WOMT), whose Federal and State agency representatives discuss the actions described in the Proposed Action when implementation may have biological, system conditions or water supply impacts or tradeoffs. These policy groups work with numerous technical groups that coordinate on seasonal and real-time operations for specific divisions or watersheds. Figure 3-10 illustrates the CVP/SWP structure for water operations.

Figure 3-11 illustrates the more specific governance structure for Shasta and Sacramento River activities, including direct coordination between SHOT and WOMT. The organizational structure for Shasta and Sacramento River activities integrates the Winter-run Action Plan to advance specific science, habitat and infrastructure initiatives.



Solid lines indicate a direct relationship for elevation and decision making, the dashed arrow between WOMT and SHOT indicates a direct line of communication and regular coordination, the dashed line between SHOT and the Trinity River Temperature Task Group indicates seasonal communication and coordination on an as-needed basis.

Figure 3-10. Governance Structure for the Central Valley Project and State Water Project Water Operations



Solid lines indicate a direct relationship for elevation and decision making, the dashed arrow between Winter-run Action Plan Team and SHOT indicates a direct line of communication and regular coordination, the dashed arrow between WOMT and SHOT indicates a direct line of communication and regular coordination, the dashed line between SHOT and the Trinity River Temperature Task Group indicates seasonal communication and coordination on an as-needed basis. The solid arrow between SHOT and the SRSCs indicates SRSC integration into SHOT.

Figure 3-11. Governance Structure for Shasta and Sacramento River Activities

3.13.3 Chartering Teams

Teams and groups involved in planning and providing input regarding water operations are described below for each division of the CVP and SWP. Team membership, roles, and processes will be described in team charters, as specified for each division below. Some teams may already have charters in place which will continue to be followed until and if replaced in the future. These charters may be supplemented by guidance documents which further elaborate roles, responsibilities, and process for these teams. These guidance documents will be updated as needed by mutual agreement.

External participants are also included in many of the Collaborative Teams to provide technical expertise and allow sharing and communication of operational decisions. The expectations and group norms for the external participants will be described in team charters.

3.13.3.1 Sacramento River Division – Water Operations

For the Sacramento River and Shasta Reservoir water operations there are three main coordination forums that will meet regularly to discuss seasonal and real-time operations. These include the SHOT, SRG, and the Winter-run JPE SubTeam. The SHOT is a policy level group that discusses water operations actions described in this Proposed Action when implementation

may have biological, system conditions or water supply impacts or tradeoffs. The SHOT also discusses activities from the Winter-run Action Plan Team that may affect water operations. It is composed of management and policy staff from participating agencies including the SRSCs. The SRG is a technical group to discuss pulse flow shaping, temperature management, fall flow smoothing and fall/winter base flows. It is composed of technical staff from Reclamation, DWR, NMFS, USFWS, CDFW, SRSCs, WAPA, the State Water Board, and Native American Tribes. The Winter-run JPE SubTeam is a technical group tasked with development of the winter-run JPE each year and the winter-run broodstock assessment. It is composed of technical staff from the 5 Agencies. Generally, topics will be discussed at a technical level through SRG with agency feedback provided prior to being discussed at the SHOT. The SHOT will coordinate regularly with WOMT and other work groups as appropriate. Sacramento River Governance will use a collaborative approach to planning and decision making.

3.13.3.1.1 Shasta Operations Team

A SHOT consisting of Agency subdirectors and managers will serve as the management and policy group for decisions related to Shasta operations. The team will develop a charter to describe membership and process. The purpose of the SHOT is to ensure agency interaction and coordination on the Sacramento River and also with the broader CVP/SWP system, including downstream demands that affect Shasta releases.

The SHOT Team will coordinate with WOMT as needed on operational issues and decisions that have implications for both of their respective purviews, including but not limited to Drought Toolkit implementation and Voluntary Agreement asset management. A summary of Shasta Reservoir operations will be communicated at WOMT meetings and documented in WOMT meeting notes.

The SHOT will meet year-round and hold monthly meetings, or as needed to coordinate on Shasta Reservoir operations and potential system-wide management actions and risks. Reclamation will provide operational outlooks and the applicable drought and dry year actions from the Drought Toolkit or other relevant drought planning documents. The SHOT may convene relevant technical teams to support Shasta or system-wide policy decisions. Reclamation will provide updates from the SHOT relevant technical teams. Each of the 5 Agencies is responsible for being informed of conditions and communicating with their respective representatives on other teams.

Consistent with the Shasta Division part of the Proposed Action, the SHOT will work together, with input from the Sacramento River Temperature and Flow Task Group, to manage Sacramento River Basin Voluntary Agreement (VA) assets. Relevant operational actions that VA assets are intended to support include Shasta Reservoir cold water pool management, seasonal pulse flows planning and fall flow management. The SHOT will consider the contribution of these assets to conditions that contribute toward maintaining flows and temperatures that support viable Chinook salmon populations by enhancing spawning, rearing, growth and migration corridors and make decisions about their deployment.

3.13.3.1.2 Sacramento River Temperature and Flow Technical Group

The Sacramento River Temperature and Flow Technical Group is a multiagency and stakeholder group established to provide technical and scientific information regarding temperature

management and instream flows. The SRG will be composed of representatives from Reclamation, DWR, USFWS, CDFW, NMFS Central Valley Office, NMFS Southwest Fisheries Science Center, the State Water Board, WAPA, the Yurok Tribe, the Hoopa Tribe and the Sacramento River Settlement Contractors. The team will develop a charter to describe membership and process. The SRG develops temperature and flow plans for implementation of temperature management, fall and winter refill and redd maintenance actions, flow smoothing for rice decomposition, spring and seasonal pulse flows, winter base flow management, ramping rates, Shasta Reservoir storage planning and relevant fishery monitoring. The SRG will work closely with Reclamation and the SHOT and will use the best available science including current hydrologic forecasts, operational outlooks, fishery information, and modeling information.

The SRG will begin meeting no later than March to develop a Draft Sacramento River Temperature Management Plan and will meet at least monthly through the temperature management and the winter-run Chinook salmon redd maintenance season to coordinate during implementation. The SRG may update the Final Temperature Management Plan at the request of the SHOT. At the conclusion of the temperature management season, the SRG will develop a summary report pursuant to seasonal and annual reporting requirements for fall and winter refill and redd maintenance actions, flow smoothing for rice decomposition, spring or other seasonal pulse flows, winter base flow management, ramping rates and relevant fishery monitoring.

Reclamation will coordinate through SRG to develop a protocol for agency collaboration regarding temperature and flow models and will strive to create shared understanding of model constraints, uncertainties, limitations, applied assumptions and interpretations; develop management questions and scenarios that may benefit from modeling support; develop and review early season operational scenarios to support temperature management and flow planning.

3.13.3.1.3 Meet and Confer Group

The SRSCs approved "A Resolution Regarding Salmon Recovery Projects in the Sacramento River Watershed, Actions Related to Shasta Reservoir Annual Operations, and Engagement in the Ongoing Collaborative Sacramento River Science Partnership Effort" (June 12, 2019). Pursuant to the resolution, during drier water years, the SRSCs will meet and confer with Reclamation, NMFS, and other agencies, as appropriate, to determine if there is any role for the SRSCs in connection with Reclamation's operational decision making for Shasta Reservoir annual operations in those years. This determination will include consideration of what actions are feasible, consistent with the terms of the SRS Contracts. In addition to the 25% reduction during Shasta Critical Years as set forth in the SRS Contracts, the types of actions that may be considered include, but are not necessarily limited to: (1) the scheduling of spring diversions by the SRSCs; (2) voluntary, compensated water transfers by the SRSCs subject to Reclamation approval; and (3) delayed SRSC diversion for rice straw decomposition during the fall months. Any mutually agreeable operations resulting from meet-and-confer discussions must be consistent with the terms of the SRS Contracts and may also be subject to other regulatory approvals.

The Meet and Confer group will be convened at the request of Reclamation, NMFS or the SRSCs at any time during the winter or spring months. According to the SRSC's resolution, this group may agree to invite the USFWS, CDFW, and/or the State Water Board at their discretion.

As part of Upper Sacramento River Governance, SHOT managers will represent the agencies at Meet and Confer meetings. The group will establish their own meeting frequency. Agency representatives from the Meet and Confer Group will communicate discussions and voluntary SRSC actions with the SPG.

3.13.3.2 Sacramento River Division – Winter-run Action Plan

For the Winter-run Action Plan, there are four main coordination forums that will meet regularly to discuss the following collaborative science, habitat and fisheries and infrastructure programs:

- The Winter-run Action Plan Team is a policy level group that discusses and coordinates the actions and milestones for the three key programs of the Winter-run Action Plan. The Winter-run Action Plan Team will also coordinate with the SHOT on science, habitat and fisheries and infrastructure actions that may affect water operations.
- The Sacramento River Science Team will work collaboratively to advance science actions identified as highest priority to be included in a science plan.
- The Sacramento River Habitat and Fishery Team will work collaboratively to advance key fishery and habitat restoration actions.
- The Infrastructure and Planning Team will work collaboratively to engage in planning and implementing key infrastructure improvements at Shasta Dam and the Livingston Stone National Fish Hatchery.

3.13.3.3 Trinity River Division – Clear Creek

The Clear Creek component of the Trinity River Division includes the Clear Creek Technical Team and SHOT. The Clear Creek Technical Team will provide technical input to Reclamation on habitat restoration and the shaping and timing of flows released from Whiskeytown Dam to optimize biological benefits downstream and provide recommendations on operations to meet temperature criteria. SHOT will coordinate with the Clear Creek Technical Team, as needed regarding Clear Creek operations that affect Shasta Operations. Trinity River Governance on Clear Creek will use a collaborative approach to planning and decision making.

3.13.3.3.1 Clear Creek Technical Team

The Clear Creek Technical Team is comprised of a group of agency representatives and interested parties who will use the best available science to provide technical input to Reclamation on habitat restoration, the shaping and timing of flows released from Whiskeytown Dam to optimize biological benefits downstream and provide recommendations on operations to meet temperature criteria. The CCTT meets quarterly, or more frequently as needed. The CCTT develops a flow schedule every year and may adjust the schedule using recent monitoring information.

3.13.3.4 Delta Division

For the Delta Division water operations there are three main agency coordination forums that will meet regularly to discuss seasonal and real-time operations. These include the WOMT, the SMT and the SaMT. WOMT is a policy level group that discusses the operations actions in the Delta, American River Division and the Stanislaus/East Side Division. The SMT is a technical

group that discusses Delta Operations and smelt protections. The SaMT is a technical group that discusses Delta Operations and salmon and steelhead protections. WOMT will coordinate regularly with SHOT and other work groups as appropriate. Delta Governance will use a collaborative approach to planning and decision making.

3.13.3.4.1 Water Operations Management Team

A WOMT will coordinate on overall water operations to oversee the implementation of various real-time provisions for the Delta and the tributaries. The purpose of WOMT is to discuss and resolve operational questions and technical issues, as requested or elevated from Delta and tributary technical teams, and to elevate unresolved operational issues to the Directors Group. The team will develop a charter to describe membership and process. The WOMT will coordinate with the SHOT as needed on operational issues and decisions that have implications for both of their respective purviews, including but not limited to Drought Toolkit implementation and Voluntary Agreement asset management.

WOMT will meet weekly during the Old and Middle River Flow Management season (October through June), and otherwise as needed. Any agency can request a WOMT meeting outside of the OMR season for discussion or elevation items. For OMR management, Reclamation will provide operational outlooks and Proposed Action assessments on a weekly basis to WOMT, the SMT and the SaMT. WOMT will be provided the opportunity to review and discuss any applicable drought and dry year actions from the Drought Toolkit or other relevant drought planning documents. For all other assessments or elevation issues, supporting materials will be provided to WOMT by designated representatives of the applicable technical teams.

3.13.3.4.2 Smelt and Salmonid Monitoring Teams

The Smelt and Salmonid Monitoring Teams (SMT and SaMT, respectively) includes participants from Reclamation, USFWS, NMFS, DWR, CDFW, and the State Water Board. The SMT and SaMT review hydrologic, operational, fishery, and water quality data, and provide opportunities for engagement and discussion among biologist and operators on relevant information and issues associated with the Proposed Action and risk assessments.

Agency team leads: (1) notify their agency's WOMT representative(s) if a Proposed Action/ITP identified trigger/threshold is or will be met; (2) provide input on any assessment prepared by Reclamation and DWR : and (3) discuss and document differing perspectives (i.e., non-consensus) on the relevant assessments.

In addition, there are also two additional groups that discuss operations that include other interested parties:

3.13.3.4.3 Delta Monitoring Workgroup

DWR and Reclamation will convene the Delta Monitoring Workgroup (DMW) if a real-time assessment in triggered. Interested parties may provide information and supporting documentation for DWR and Reclamation to share with WOMT. If WOMT does not reach consensus on an operational outcome, interested party supporting documentation will be provided to the Directors for consideration of their final decision. DWR and Reclamation will revise the existing Delta Monitoring Workgroup charter within six months of the ROD.

3.13.3.4.4 Delta Coordination Group

The DCG is comprised of two representatives each from Reclamation, NMFS, USFWS, DWR and CDFW, and one representative each from the CVP water contractors and SWP water contractors. The DCG may prepare an assessment to propose an alternative gate operation to the Suisun Marsh Salinity Control Gate action and will develop an annual monitoring plan for the action. The DCG will participate in the development of food subsidy action plans, monitoring plans, and reports.

3.13.3.5 American River Division

For the American River Division water operations there are two main coordination forums that will meet regularly to discuss seasonal and real-time operations. These include the WOMT and ARG. The ARG is a technical group that discusses reservoir and storage planning, forecasting and seasonal operations, flow and water temperature management and monitoring programs. American River Governance will use a collaborative approach to planning and decision making.

3.13.3.5.1 American River Group

A group of federal, state, and local agencies, water users, and non-governmental organizations (NGOs) makes up the ARG to coordinate the shaping of releases including spring pulse flow timing and longevity, communicate upcoming releases, discuss water operations, fisheries, and other environmental concerns and to share operational and biological information with the goal of improving the technical understanding of Lower American River temperature needs and operational constraints and considerations.

The ARG meets monthly, or more frequently as needed. The ARG will (a) evaluate the equations used to calculate the MRRs in November through December to consider whether an adjustment to the maximum MRR is warranted based on habitat improvements and other relevant information, and (b) submit a recommendation to Reclamation. The ARG will provide technical input on shaping Flow volumes, with the final timing determined by CDFW, FWS, and NMFS. The ARG will provide technical input on shaping Redd Dewatering Projective Adjustments. The draft Temperature Management Plan will be shared with the ARG, and Reclamation will consider feedback from ARG participants before finalizing the plan by June 15. During plan implementation, if the water temperature threshold is exceeded for 3 consecutive days, or is exceeded by more than 3°F for a single day, Reclamation will notify NMFS and the ARG, and outline steps being taken to bring the water temperature back into compliance.

3.13.3.6 East Side Division - Stanislaus River

For the East Side Division – Stanislaus River there are two main coordination forums that will meet regularly to discuss seasonal and real-time operations. These include the WOMT and the Stanislaus Watershed Team (SWT). The SWT is a technical group that discusses reservoir and storage planning, forecasting and seasonal operations, flow and water temperature management and monitoring programs. The SWT will coordinate with other groups as appropriate. East Side - Stanislaus River Governance will use a collaborative approach to planning and decision making.

3.13.3.6.1 Stanislaus Watershed Team

SWT is a group of agency representatives and local interested parties (including conservation groups and other organizations working directly on Stanislaus River issues) having direct interest

on the Stanislaus River. The SWT will provide technical input to Reclamation on the shaping and timing of monthly or seasonal flow volumes to optimize biological benefits. The SWT will meet at least monthly to share operational information and improve technical dialogue on the implementation of the New Melones SRP.

In addition, there is one additional group that discusses operations that includes other interested parties:

3.13.3.6.2 Stanislaus River Forum

The Stanislaus River Forum is an open forum for all interested stakeholders to receive Stanislaus River Operations updates and to provide feedback for SWT and Reclamation consideration. The Stanislaus River Forum will meet at least monthly and prior to the SWT meeting to share operational information and improve technical dialogue on the implementation of the New Melones SRP.

3.13.4 Collaborative Decision Making

This section describes the representatives and the process for elevation, decision making, and communication. More information on the types of decisions and process for each Division can be found in the corresponding section of the LTO Proposed Action.

3.13.4.1 Directors

Directors from Reclamation, DWR, USFWS, NMFS and CDFW will meet as requested by the WOMT or the SHOT when consensus cannot be reached on operations. The team that is the lead for the elevation issue will notify the other team prior to elevating to the Directors to ensure full transparency.

3.13.4.1.1 Director Decision Making for Shasta and Tributaries

The Regional Director for Reclamation will confer with the other Directors to determine if there is an alternative action that will be mutually agreeable. If consensus is reached, Reclamation will implement the alternative action. If the Directors do not reach a resolution on operations, Reclamation will make a decision and notify the other Directors in writing. Any Director has the opportunity to dispute a decision within 2 days, providing a written explanation of the nature of the dispute. Reclamation will respond in writing within 2 days after receiving the explanation for the disputed action and before taking an action. Any Director may request a follow-up Directors meeting if necessary.

If there is disagreement on an operational action that Reclamation determines may create a potentially high risk to CVP infrastructure or liability to the United States, then Reclamation will make the final decision as to whether or not to implement that action.

3.13.4.1.2 Director Decision Making for the Delta

The Regional Director of Reclamation or DWR (proposing agency or agencies) will confer with the fish agency Directors/Regional Administrator to determine if there is an alternative action that will be mutually agreeable for specific areas that rely on a risk assessment, following elevation by WOMT. If consensus is reached, the proposing agencies will implement the alternative action. If the Directors do not reach a resolution on operations, the proposing agencies

will meet and confer to prioritize alignment between the SWP and CVP operations, in consideration of operational and regulatory constraints affecting either project, will make a decision and notify the other Directors in writing. Any Director has the opportunity to dispute a decision within 2 days, providing a written explanation of the nature of the dispute. The proposing agencies will respond in writing within 2 days after receiving the explanation for the disputed action and before taking an action. Any Director may request a follow-up Directors meeting if necessary.

If there is disagreement on an operational action that the proposing agency determines may create a potentially high risk to Project infrastructure or liability to the United States or State of California, then the proposing agency will make the final decision as to whether or not to implement that action.

Once a decision has been resolved following any of the procedures described above, the Directors will designate a representative or representatives to communicate the decision to relevant parties, including operators, technical team representatives, and/or other interested parties.

3.13.4.2 Water Operations Management Team

Each agency is responsible for being informed of conditions and communicating with their respective representatives on other teams. If issues that are elevated to WOMT are resolved by WOMT, an agency representative will be designated by WOMT to communicate the decision via email to relevant technical team representatives. If the WOMT cannot reach consensus on an operational issue, the issue will be elevated to the Directors through the subdirectors. Similarly, if the SHOT or WOMT have an operational disagreement, the issue will be elevated to the Directors through the subdirectors. The elevation process will be managed collaboratively by the WOMT.

3.13.4.3 Shasta Water Operations Team

Each agency is responsible for being informed of conditions and communicating with their respective representatives on other teams. If issues that are elevated to SHOT are resolved by SHOT, an agency representative will be designated to communicate the decision via email to relevant technical team representatives. If the SHOT cannot reach consensus on an operational issue, the issue will be elevated to the Directors through the subdirectors. Similarly, if the SHOT or WOMT have an operational disagreement, the issue will be elevated to the Directors through the subdirectors. The elevation process will be managed collaboratively by the SHOT.

Consistent with the Proposed Action for the Shasta Division, the SHOT will work together, with input from the Sacramento River Settlement Contractors, to manage Sacramento River Basin Voluntary Agreement (VA) assets. The SHOT will consider the contribution of these assets to conditions that contribute toward maintaining flows and temperatures to support viable Chinook salmon populations by enhancing spawning, rearing, growth and migration corridors. Relevant operational actions that VA assets will support include, but are not limited to, Shasta cold water pool management, seasonal pulse flows and fall flow management. Fish agencies will be the final decision makers on deployment of VA assets based on what provides the best protection for the species.

3.13.4.4 Sacramento River Temperature and Flow Technical Group

Each participating agency is responsible for being informed of conditions and communicating with their respective representatives on other teams. SRG will seek to reach consensus. If consensus is not reached, at the close of SRG meetings, there will be an Agency resolution session to discuss and compose an e-mail to SHOT, summarizing the elevation topic and any supporting information and recommendation, and report the details of the elevation issue to SHOT. Each of the five agency representatives are individually responsible for communicating the issue and any background information to their SHOT representative. The decision making process will then follow the procedure described in the SHOT section above and, if necessary, the procedure in the Directors section above.

3.13.4.5 Winter-run Action Plan Team

Reclamation is committed to support a separate Winter-Run Action Plan with NMFS, FWS, CDFW, DWR and SRSCs to pursue a science and monitoring plan, winter-run habitat and infrastructure actions, and water operations.

3.13.4.6 Clear Creek Technical Team

Each participating agency is responsible for being informed of conditions and communicating with their respective representatives on other teams. CCTT proposed flows will be routed to Central Valley Operations, who will implement the flows as proposed. If there is an operational issue that the CCTT cannot resolve, the Agency representatives will compose an e-mail to SHOT, summarizing the elevation topic and any supporting information and recommendations. Each of the agency representatives is individually responsible for communicating the issue and any background information to their SHOT representative. The decision making process will then follow the procedure described in the SHOT section above and, if necessary, the procedure in the Directors section above.

3.13.4.7 American River Group

Each participating agency is responsible for being informed of conditions and communicating with their respective representatives on other teams. If there is an operational issue that the ARG cannot resolve, the Agency representatives will compose an e-mail to WOMT, summarizing the elevation topic and any supporting information and recommendations. Each of the Agency representatives is individually responsible for communicating the issues and any background information to their WOMT representative. The decision making process will follow the procedure described in the WOMT section above and, if necessary, the procedure in the Directors section above.

3.13.4.8 Smelt and Salmonid Monitoring Teams

Each participating agency is responsible for being informed of conditions and communicating with their respective representatives on other teams. Agency team leads: (1) notify their agency's WOMT representative(s) if a Proposed Action/ITP identified trigger/threshold is or will be met; (2) provide input on the Proposed Action assessment and any assessment prepared by Reclamation and DWR : and (3) discuss and document differing perspectives (i.e., non-consensus) on the relevant assessments. If there is an operational issue that the team cannot resolve, the Agency representatives will compose an e-mail to WOMT, summarizing the

elevation topic and any supporting information and recommendations. Each of the Agency representatives is individually responsible for communicating the issues and any background information to their WOMT representative. The decision making process will follow the procedure described in the WOMT section above and, if necessary, the procedure in the Directors section above.

3.13.4.9 Stanislaus Watershed Team

Each participating agency is responsible for being informed of conditions and communicating with their respective representatives on other teams. If there is an operational issue that the SWT cannot resolve, the Agency representatives will compose an e-mail to WOMT, summarizing the elevation topic and any supporting information and recommendations. Each of the Agency representatives is individually responsible for communicating the issues and any background information to their WOMT representative. The decision making process will follow the procedure described in the WOMT section above and, if necessary, the procedure in the Directors section above.

3.14 Adaptive Management

Adaptive management is a structured, iterative process for decision making when confronted with uncertainty. It emphasizes learning through management where knowledge is incomplete and provides a process for building knowledge through monitoring and science, reducing uncertainty, and improving management over time in a goal-oriented and structured way. Key components of adaptive management are establishing clear and measurable objectives, identifying action goals, and determining management options for best achieving those desired goals.

Decision support tools can be used within the adaptive management framework to identify the uncertainties that are most influential in a decision making process (management), which in turn can guide the scientific approaches deployed to reduce those uncertainties and allow better informed subsequent decisions. When correctly designed and executed, adaptive management provides a means to develop and evaluate the expected outcomes of proposed management actions, to compare actual outcomes of actions to those expectations, and to make evidence-based adjustments to future actions to improve their effectiveness if warranted. The adaptive management approach can provide a transparent and documented scientific basis for continuing, modifying, or implementing an alternative action.

DWR, CDFW, Reclamation, USFWS, and NMFS (collectively, “the Implementing Entities”) intend to utilize adaptive management to inform the long-term operations of the SWP and the CVP and related activities described herein. The Implementing Entities will approach adaptive management in an open, participatory framework. The Implementing Entities will establish the Adaptive Management Steering Committee to coordinate through individual Adaptive Management Teams responsible for evaluating each Adaptive Management Action, utilizing decision support tools such as structured decision making.

Working through the collaborative process outlined in this document, the Implementing Entities commit to reach consensus within the Adaptive Management Steering Committee to the maximum extent possible, while still retaining individual agency discretion to make decisions (as appropriate). To that end, the Implementing Entities seek to use the potential flexibility provided by an adaptive management approach in a way that balances gaining knowledge to improve future management decisions while taking actions in the face of uncertainty to improve the operation of the CVP and SWP for their project purposes.

The Adaptive Management Program is described in Appendix R. Attachment 1 to the Adaptive Management Program describes the steps required to implement the adaptive management process and explains how the process links to the operations of the SWP and CVP. Attachment 2 to the Adaptive Management Program includes a list of actions and programs in the Proposed Action (listed below), and additional details regarding the timeframe of evaluation of each action and the Adaptive Management Teams responsible for implementing them:

- Winter-run Chinook Salmon OMR Management
- Spring-run Chinook Salmon OMR Management
- Summer-Fall Habitat Action for Delta Smelt
- Tidal Habitat Restoration Effectiveness for Smelt Fishes
- Tributary Habitat Restoration Effectiveness for Salmonid Fishes
- Shasta Spring Pulse Flow Studies
- Winter-run Chinook Salmon Through Delta Survival Targets
- Longfin Smelt Science Plan Actions
- Delta Smelt Supplementation
- Steelhead JPE
- Alternative Salmonid Loss Estimation Pilot Study
- Shasta Cold Water Pool Management
- Georgiana Slough Migratory Barrier Effectiveness for Salmonid Fishes
- Spring Outflow
- Clear Creek

3.15 Framework Programmatic Outline for Sites Reservoir Project and Delta Conveyance Project

The Long-Term-Operations consultation (LTO) is a mixed programmatic action, as defined in 50 CFR 402.02[15]. This consultation includes a mix of standard consultation and programmatic consultation (which can include an Incidental Take Statement or defer the Incidental Take Statement to a later time associated with subsequent Federal actions). All activities addressed programmatically will be subject to a subsequent consultation in order to proceed. Additionally, some project elements and their effects on listed species or critical habitat may change as Reclamation and DWR continue to develop the Proposed Action for the programmatic elements and may require reinitiation of consultation.

This Proposed Action provides a framework for the development of future Federal actions that will be authorized, funded, or carried out at a later time and will be subject to future project-specific consultations because of these subsequent Federal actions. Reclamation will initiate these future consultations and will provide sufficient information as outlined in 50 CFR 402.12(t). The Services will complete these future consultations and that additional review will be informed by sufficient detail to allow the development of incidental take statements for each of these activities.

This Proposed Action includes a programmatic framework consultation for the operations of the Sites Reservoir Project (Sites) and the operations of the proposed Delta Conveyance Project (DCP). The use of a mixed programmatic framework consultation for these two projects provides information, to the extent possible given the information available today, to assess how these projects would operate in the context of the LTO Proposed Action along with broadly assessing the impacts of the operations of these projects in the context of the LTO Proposed Action. The use of a mixed programmatic framework consultation for these two projects provides information, to the extent possible, on how these key projects would be implemented, if approved after completing compliance with the California Environmental Quality Act (CEQA), in conjunction with the LTO operations in the future and will support subsequent regulatory processes and coordinated operations planning.

Reclamation proposes to initiate section 7 consultation for the non-operational construction and maintenance components of Sites and U.S. Army Corps of Engineers proposes to initiate section 7 consultations for the non-operational construction and maintenance components of the DCP, both separately from LTO. These construction-focused consultation efforts will proceed in-parallel with this Proposed Action.

[15] Mixed programmatic action means, for purposes of an incidental take statement, a Federal action that approves action(s) that will not be subject to further section 7 consultation, and also approves a framework for the development of future action(s) that are authorized, funded, or carried out at a later time and any take of a listed species would not occur unless and until those future action(s) are authorized, funded, or carried out and subject to further section 7 consultation.

In the future, Reclamation also proposes to initiate section 7 consultation for the operational components of Sites and DCP. As these separate future consultations are completed for each project and as Reclamation makes a decision regarding each project, each will become part of the Environmental Baseline and will need to be incorporated into the modeled baseline condition for subsequent projects, including any future reinitiations of consultation for LTO. In order to ensure effects of Sites and DCP are sufficiently addressed, those separate section 7 consultations, including construction-focused consultation efforts noted above, will reference this framework when addressing the effects of operations of each of these projects. Reclamation will ensure that section 7(d) is adhered to by ensuring operations will not commence before completion of project-specific section 7 consultation for operations. In addition, implementation of any potential construction-related activities prior to completion of the future section 7 operations consultation would not affect the requirement for Reclamation to implement, if necessary, Reasonable or Prudent Alternatives identified during subsequent consultation.

Project descriptions for the proposed Sites and DCP, as well as the proposed approach for considering operational effects of Sites and DCP in relation to the updated LTO Proposed Action, are provided below and are proposed to be addressed programmatically.

3.15.1 Future Project Considerations and Regulatory Processes

Both the Sites and DCP projects are subject to future consultations under Section 7 of the ESA. Both projects are subject to the requirements of Section 2081 of the California Endangered Species Act (CESA) and future coordination with CDFW will likely be required to ensure consistency with compliance under both the ESA and CESA. Since it will be several years before these projects become operational, there are other factors (e.g., climate change) that will need to be addressed in future project design modifications, as feasible, and operational criteria refinements. In addition, there are other regulatory processes and approvals that could influence final operation of these projects or final design. These potential changes would need to be addressed in the future ESA consultations. These future processes include, but are not necessarily limited to:

- Completion of CEQA and a decision on whether to approve Sites, or an alternative, by the Sites Authority and the DCP, or an alternative, by DWR; additional CEQA compliance may be necessary where additional discretionary decisions require review of new information, a change in circumstances, or change in the project.
- The water rights process administered by the State Water Board for both Sites and DCP, which is expected to result in separate water rights orders that may limit how water will be diverted from the Sacramento River. DWR is not proposing to increase the existing SWP water right for DCP and will only request a change in point of diversion for the SWP water rights. Sites is petitioning the State Water Board to obtain new water rights for diversion and storage.
- Updates to the Bay-Delta Water Quality Control Plan by the State Water Board, which may result in changes in the operational parameters for both Sites and DCP.
- Consistency with the Delta Plan for DCP per the requirements of the Delta Reform Act.

- Coordinated operations agreement(s) between Reclamation and DWR (and Sites for Sites operations) which will need to incorporate DCP and Sites into the existing CVP and SWP coordinated operations system and would specify how water will be transferred, exchanged, and exported.
- Authorizations from the U.S. Army Corps of Engineers under the Clean Water Act and Rivers and Harbors Act for certain aspects of each project.

3.15.2 Qualitative Project Descriptions

Qualitative descriptions of the proposed projects and potential operational effects for both Sites and DCP individually, as well as combined, are included in this framework. Potential for effects on storage in upstream reservoirs, potential for changes in flows and temperatures upstream of Sites and DCP, changes in flows adjacent to Sites and DCP facilities, and changes in flows and hydrodynamics through, and downstream of, the Delta are all addressed at a programmatic level. These operationally driven changes in flows will be considered in the context of the Sacramento River, Delta, and downstream aquatic ecosystems, and specifically in relation to ESA listed species and critical habitat.

3.15.3 Sites Reservoir

Sites would involve the construction, operation, and maintenance of a 1.5 million acre-foot offstream surface water reservoir to provide direct and real benefits to instream flows, the Delta ecosystem, and water supply reliability. The reservoir inundation area would be in rural, unincorporated areas of Glenn and Colusa Counties, and project components would be located in Tehama, Glenn, Colusa, and Yolo counties.

The Project would use existing infrastructure to divert unregulated and unappropriated flow from the Sacramento River at Red Bluff and Hamilton City and convey the water to a new offstream reservoir west of the community of Maxwell, California. New and existing facilities would move water into and out of the reservoir. Releases from Sites Reservoir would be used locally, be conveyed to the Yolo Bypass for ecosystem benefits, or ultimately return to the Sacramento River system via existing canals and a new pipeline located near Dunnigan. Water released from the reservoir would be used to benefit local, state, and federal water use needs, including public water agencies, anadromous fish species in the Sacramento River watershed, wildlife refuges and habitats, and the Yolo Bypass to help supply food for delta smelt (*Hypomesus transpacificus*). The Authority would own and operate all newly constructed

project facilities that are not already owned by another entity. There are currently 22 Storage Partners representing local and regional water delivery agencies that serve over 24.5 million people and over 500,000 acres of farmland that are paying for the Project and would receive the resulting water supply benefits. In addition, the State of California, through the California Water Commission, and the Bureau of Reclamation are also envisioned to be Storage Partners and receive water supply benefits.

The objectives of the project are as follows:

- Improve water supply reliability and resiliency to meet Storage Partners' agricultural and municipal long-term average annual water demand in a cost-effective manner for all Storage Partners, including those that are the most cost sensitive.
- Provide public benefits consistent with Proposition 1 of 2014 and use Water Storage Investment Program funds to improve statewide surface water supply reliability and flexibility to enhance opportunities for habitat and fisheries management for the public benefit through a designated long-term average annual water supply.
- Provide public benefits consistent with the Water Infrastructure Improvements for the Nation Act (WIIN Act) by using federal funds, if available, provided by Reclamation to improve CVP operational flexibility in meeting CVP environmental and contractual water supply needs and improving cold water pool management in Shasta Lake to benefit anadromous fish.
- Provide surface water to convey biomass from the floodplain to the Delta to enhance the Delta ecosystem for the benefit of pelagic fishes in the north Delta (e.g., Cache Slough).
- Provide local and regional amenities, such as developing recreational facilities, reducing local flood damage, and maintaining transportation connectivity through roadway modifications.

Reclamation's role in the Sites Reservoir Project is as a funding partner. Reclamation would acquire a water storage account in Sites Reservoir and an additional water supply it may use to supplement its existing supplies. Reclamation's purposes for the project include the following:

- Increased water supply and improved reliability of water deliveries
- Increased CVP operational flexibility
- Benefits to anadromous fish by improving CVP operations consistent with the laws, regulations, and requirements in effect at the time of operation
- Incremental Level 4 water supply for CVP Improvement Act refuges
- Delta ecosystem enhancement by providing water to convey food resources

The operational components of the Sites Project are listed in Table 3-16. The Sites Project is sufficiently developed for consideration at a framework level consistent with the 1992 CVPIA and 2016 WIIN Act. Reclamation and the Sites Project Authority recently completed the Sites Reservoir Project Final Environmental Impact Report/Environmental Impact Statement (Final Environmental Impact Report/Environmental Impact Statement - Sites Reservoir (sitesproject.org)) that analyzes the impacts of the project and is included in this Biological Assessment by reference.

Table 3-15. Operational Programmatic Components of Proposed Sites Project

Sites Project Activity	Description
Diversions to Sites Reservoir, Operating Criteria, and Diversion Criteria	All aspects of diversion of water at Red Bluff Pumping Plant, Hamilton City Pump Station, Stone Corral Creek, and Funks Creek, including the use of excess capacity in the Tehama-Colusa Canal and Glenn-Colusa Irrigation District Main Canal to convey water to the reservoir and storage of water in Sites Reservoir. Specific descriptions of pulse protection at Bend Bridge, bypass flows at Red Bluff, Hamilton City and Wilkins Slough, and other diversion criteria are specified in Chapter 2, Section 2.5.2.1, page 2-78 through page 2-86 of the Sites Project Final EIR/EIS.
Water Conveyance and Releases from Sites Reservoir	Releases of water from Sites Reservoir into the Tehama-Colusa Canal, Glenn-Colusa Irrigation District Main Canal, Stone Corral Creek, and Funks Creek. Conveyance of water from the Tehama-Colusa Canal into the Dunnigan Pipeline and subsequent release into the Colusa Basin Drain and ultimately into the Sacramento River or Yolo Bypass. Releases from Sites Reservoir are described in Chapter 2, Section 2.5.2.1, page 2-86 through 2-88 and page 2-90 through 2-91 of the Sites Project Final EIR/EIS.
Coordination with CVP and SWP	Exchanges with Shasta Lake and Lake Oroville, including Reclamation's investment in Sites Reservoir as described in Chapter 2, Section 2.5.2.1, page 2-88 through 2-90 of the Sites Project Final EIR/EIS.
Flood Control	Flood control benefits to the communities of Maxwell and Colusa, local agricultural lands, rural residences, and Interstate 5 by impounding Funks Creek and Stone Corral Creeks as described in Chapter 2, Section 2.5.2.1, page 2-91 through 2-92 of the Sites Project Final EIR/EIS
Emergency Releases	Operation of facilities to meet Division of Safety of Dams criteria and requirements for emergency reservoir drawdown as described in Chapter 2, Section 2.5.2.1, page 2-92 of the Sites Project Final EIR/EIS
Energy Generation and Energy Use	The as described in Chapter 2, Section 2.5.2.2, page 2-92 through 2-93 of the Sites Project Final EIR/EIS generation of energy in operations and use of energy for operations
Aquatic Monitoring and Adaptive Management	Implementation of an aquatics monitoring and adaptive management plan to (1) integrate the Project's adaptive management program with existing monitoring and science programs; (2) provide the proposed framework and governance, and (3) include the process for adaptive management, including operational criteria and conservation measures as described in various spots in Chapter 2 and Appendix 2D (2D.4, 2D.5, 2D.6) of the Sites Project Final EIR/EIS
Compensatory Mitigation for Temporary and Permanent Impacts	Species-specific compensatory mitigation actions that would be completed prior to operations as may be required in the projects permits and approvals

Construction of Sites Reservoir is expected to take approximately 7 years, beginning in 2026 and concluding in 2032. Currently, the reservoir is expected to be substantially completed in 2032 with filling beginning in 2033. The amount of time it would take to fill Sites Reservoir would depend greatly on hydrology and how Storage Partners choose to use their water during initial filling. Initial filling could range from approximately 2 years to over 10 years.

3.15.4 Delta Conveyance Project

On April 29, 2019, Governor Newsom signed Executive Order N-10-19 directing the California Natural Resources Agency, California Environmental Protection Agency, and California Department of Food and Agriculture to develop a comprehensive strategy to build a climate-resilient water system and ensure healthy waterways through the twenty-first century. After a public input period, Governor Newsom released the California Water Resilience Portfolio on July 28, 2020. The Water Resilience Portfolio identifies a suite of complementary actions to ensure safe and resilient water supplies, flood protection and healthy waterways for the state's communities, economy, and environment. One of the projects identified in the portfolio is new diversion and conveyance facilities in the Delta to safeguard the SWP, which is now proposed as the Delta Conveyance Project. DWR proposed and is evaluating the project consistent with the portfolio approach and is currently reviewing the proposed project under CEQA with a Final Environmental Impact Report and decision on approval expected by the end of 2023.

DWR's fundamental purpose in proposing the DCP is to develop new intake and conveyance facilities in the Delta is to restore and protect the reliability of SWP water deliveries and, potentially, CVP water deliveries south of the Delta, consistent with the State's Water Resilience Portfolio in a cost-effective manner. This purpose, in turn, gives rise to the following project objectives.

- To help address anticipated rising sea levels and other reasonably foreseeable consequences of climate change and extreme weather events.
- To minimize the potential for public health and safety impacts from reduced quantity and quality of SWP water deliveries, and potentially CVP water deliveries, south of the Delta as a result of a major earthquake that could cause breaching of Delta levees and the inundation of brackish water into the areas where existing SWP and CVP pumping plants operate in the southern Delta.
- To protect the ability of the SWP, and potentially the CVP, to deliver water when hydrologic conditions result in the availability of sufficient amounts of water, consistent with the requirements of state and federal law, including the CESA and ESA and Delta Reform Act, as well as the terms and conditions of water delivery contracts and other existing applicable agreements.
- To provide operational flexibility to improve aquatic conditions in the Delta and better manage risks of further regulatory constraints on project operations.

The proposed DCP project includes the construction and operation of new water intake facilities on the Sacramento River in the north Delta and a single main tunnel to divert and move water entering the north Delta from the Sacramento Valley watershed to existing SWP facilities in the south Delta, which would result in a dual conveyance system for the SWP in the Delta (see Table 3-17 for additional details on operations of the proposed project [i.e., DCP Public Draft EIR Alternative 5, Bethany Reservoir Alignment]). DWR is not seeking to increase its existing water rights, nor is it proposing any operational changes upstream of the Delta. The DCP, if approved, would be a part of the SWP's integrated water delivery system and, therefore, would be considered within the SWP and CVP Long-Term-Operations. If the DCP is approved and implemented by DWR, it would be a part of the SWP Delta operations and subject to Reclamation and DWR COA.

DWR would implement "dual conveyance" by operating the proposed north Delta diversion in conjunction with the existing south Delta diversion system for the SWP. During winter and spring, operations of existing south Delta water export facilities would be prioritized up to what is permitted under the existing water rights and all applicable state and federal law and regulations, before operating the proposed north Delta intakes. During summer/fall, operations would be focused on more efficient Delta salinity management. The south Delta exports and the north Delta diversions would be balanced and adjusted to meet the State Water Board D-1641 salinity requirements at the western Delta stations on the Sacramento and San Joaquin Rivers (e.g., increasing salinity at Jersey Point would cause a shift in diversions from south Delta to north Delta, whereas increasing salinity at Emmaton would cause a shift from north Delta to south Delta). This operation is expected to result in a more efficient system operation.

For purposes of the USACE DCP BA, project-specific effects associated with construction and placement of DCP facilities, including in-water work, as well as both temporary and permanent impacts, will be covered under the USACE's section 7 consultation. All effects associated with the north Delta diversion intake operations, including near- and far-field effects within the river as well as potential associated effects on aquatic biological resources, are assessed through the Programmatic LTO analysis. Table 3-17 describes key operational programmatic components of the Proposed Project.

Table 3-16. Operational Programmatic Components of Delta Conveyance Project

DCP Project Activity	Description
North Delta Intake Diversions	The proposed intakes would augment the ability to capture excess flows and improve the flexibility of SWP operations (e.g., improved salinity management during the summer/fall). New operational criteria would govern the diversions at the proposed north Delta intakes to minimize effects near and downstream of the new intakes. See Section 3.16 of the DCP Public Draft EIR for additional details on project operations.
SWP Integration	The north Delta intakes would operate in conjunction with the existing SWP south Delta intakes. For example, during the winter and spring, the SWP would first use south Delta facilities to export water up to what is permitted under the existing water rights and all applicable state and federal law and regulations before diverting from the new north Delta intakes. Upstream SWP storage

DCP Project Activity	Description
	operations would continue to be managed to the existing and future regulatory and contractual obligations of the SWP in determining the amount of stored water available for exports. The DCP would not change operational criteria associated with upstream reservoirs (Section 3.16.3, DCP Public Draft EIR).
Coordination with CVP	Continued SWP coordination with CVP through the Coordinated Operations Agreement, consistent with applicable regulatory requirements (Section 3.16, DCP Public Draft EIR).
Adaptive Management and Monitoring Program	The Adaptive Management and Monitoring Program would be used to evaluate and consider changes in operational criteria, if necessary, based on information gained before and after the new facilities become operational. This program would be used to consider and address scientific uncertainty regarding the Delta ecosystem and potential effects of the project. In addition, an adaptive management and monitoring plan would be prepared for each mitigation site to help ensure habitat creation goals are met. (Section 3.18, DCP Public Draft EIR).
Conservation Measures	Included to avoid, minimize, and offset effects of the proposed action on listed species. This includes compensatory mitigation to be completed prior to operations at the acreages identified for each species. (Appendix 3F, DCP Public Draft EIR).

3.15.5 Combined Qualitative Description

Both DCP and Sites are designed to improve water management capabilities for SWP and CVP and collectively respond to challenges associated with future climate change. In particular, the projects would provide for facility updates and improve the ability for SWP and CVP to respond to more extreme weather, driven by climate change, by improving the ability to capture, store, and convey water associated with flashier flow events, as well as a predicted general shift in hydrograph with relatively higher flows in winter months and reductions in the spring. As described qualitatively above, both DCP and Sites incorporate operational criteria to minimize potential effects on the environment and aquatic resources both at the facilities (near-field) as well as downstream (far-field). While these criteria have been designed to integrate with existing regulations and reduce potential effects of each project individually, there are potential interactive effects which are important to further investigate and account for, mainly associated with changes to Sacramento River flows upstream of, in, and through the Delta. Potential effects on aquatic resources associated with these changes include:

- Changes to timing, magnitude, and duration of flows along the Sacramento River/Delta corridor.
- Subsequent changes to important aquatic constituents (e.g., suspended sediment, nutrients, lower trophic production) associated with the flow modifications.
- Potential changes to quantity/quality of habitat supporting listed species spawning, rearing, and migration.

- Potential changes in production of listed aquatic species.

Additionally, upstream changes (i.e., Shasta reservoir storage, upper Sacramento River flows – for Sites; Oroville reservoir storage, upper Feather River flows – indirectly for DCP) may have non-intuitive interactive effects of the combined projects and will also be explored. Generally, the effects on these locations would be improvements in upstream storage and cold water flexibility, relative to no action, based on the projects' objectives.

3.15.6 Quantitative Project Descriptions

This section contains quantitative descriptions of the modeled results comparing Sites and DCP operational effects relative to the updated LTO. The quantitative effects analysis will focus on key indicators of biological/ecological relevance such as storage, flows, and temperatures at key locations on the Sacramento River, as well as through and downstream of the Delta.

3.15.7 Analysis and Comparative Modeling Results

Sites and DCP have assessed their operations as part of their CEQA (and also the National Environmental Policy Act for Sites) compliance efforts. This quantitative information helps inform the programmatic consideration of this framework. These analyses have led to the development of detailed operational criteria to reduce or avoid operational effects on sensitive species, and these criteria are described further below.

3.15.7.1 Sites Reservoir

Sites Reservoir would be filled through the diversion of Sacramento River water that generally originates from unregulated tributaries to the Sacramento River downstream from Keswick Dam. Diversions to Sites Reservoir could also come from flood releases from Shasta Lake. Diversions to Sites Reservoir would be made from the Sacramento River at the existing Red Bluff Pumping Plant (RBPP) (RM 243) near Red Bluff into the Tehama-Colusa Canal and at the existing Glenn-Colusa Irrigation District (GCID) Hamilton City Pump Station (RM 205) near Hamilton City into the GCID Main Canal. Water could be diverted to storage in Sites Reservoir from September 1 to June 14. Diversions would occur only when all of the following conditions are met:

- Flows in the Sacramento River exceed the minimum diversion criteria (described in Table 3-18);
- The Delta is in "excess" conditions as determined by Reclamation and DWR and would remain in excess conditions during diversions;
- Senior downstream water rights, existing CVP and SWP and other water rights diversions including Section 215 of the Reclamation Reform Act of 1992, Article 3(f) water, and SWP Article 21 (interruptible supply), and other more senior flow priorities have been satisfied;
- Flows are available for diversion above flows needed to meet all applicable laws, regulations, biological opinions and incidental take permits, and court orders in place at the time that diversion occurs. This would include but is not limited to any flow requirements in Water Right Decision 1641 (State Water Resources Control Board 2000),

the 2019 biological opinions for the reinitiation of consultation on coordinated long-term operations of the CVP and SWP (ROC on LTO BiOps) (U.S. Fish and Wildlife Service 2019; National Marine Fisheries Service 2019) and any future related BiOps, and the State incidental take permit (California Department of Fish and Wildlife 2020); and

- There is available capacity at the RBPP and in the Tehama-Colusa Canal and GCID facilities to divert and convey water to Sites Reservoir, above the capacity needed for deliveries to existing Tehama-Colusa Canal users and within the GCID service area.

The RBPP would serve as the primary diversion location and would divert water from the Sacramento River to Funks Reservoir through the Tehama-Colusa Canal and into the Sites Reservoir through the Funks Pumping and Generating Plant and the Inlet/Outlet Works. A maximum of approximately 2,120 cfs would be diverted at the RBPP for the project. The Hamilton City Pump Station would serve as the secondary diversion location and would divert water from the Sacramento River to the new Terminal Regulating Reservoir through the GCID Main Canal and into the Sites Reservoir through the Terminal Regulating Reservoir Pumping and Generating Plant and the Inlet/Outlet Works. A maximum of approximately 2,070 cfs would be diverted at the Hamilton City Pump Station for the project. Although the RBPP would be the primary diversion point, both diversion facilities would be operated simultaneously when river conditions and capacity are available for a maximum combined diversion rate of about 4,200 cfs (3,900 cfs, plus losses). Table 3-18 provides a summary of the Sites project minimum diversion criteria.

Table 3-17. Summary of Project Diversion Criteria (this is Table 2-5 from the Final EIR/EIS)

Location (Listed from North to South)	**Criteria**
Bend Bridge Pulse Protection	Protection of all qualified precipitation-generated pulse events (i.e., peaks in river flow rather than scheduled operational events) from October to May based on predicted hydrology and monitoring. A criterion based on the detection of migrating fish may be added if a fish monitoring method can be demonstrated as effective and reliable. A qualified precipitation-generated pulse event is determined based on forecasted flows, and pulse protection may cease after 7 days or earlier if flows at Bend Bridge exceed 29,000 cfs and Project diversions subtracted from Bend Bridge flows continue to be at least 25,000 cfs.
Minimum Bypass Flows in the Sacramento River at the RBPP	3,250 cfs minimum bypass flow at all times; rate of diversion controlled by fish screen design
Minimum Bypass Flows in the Sacramento River at the Hamilton City Pump Station	4,000 cfs minimum bypass flow at all times; rate of diversion controlled by fish screen design
Minimum Bypass Flows in the Sacramento River at Wilkins Slough	10,700 cfs from October 1 to June 14; 5,000 cfs in September (no diversions to Sites Reservoir from June 15 to August 31)

Location (Listed from North to South)	Criteria
Freeport, Net Delta Outflow Index, X2, and Delta Water Quality	Operations consistent with all applicable laws, regulations, biological opinions and incidental take permits, and court orders in place at the time that diversion occurs

cfs = cubic feet per second; RBPP = Red Bluff Pumping Plant.

The Sites project diversion criteria have been analyzed extensively and are not expected to change substantially. However, criteria may be refined in actual project operations through adaptive management and in coordination with the fisheries agencies. In particular, adaptive management actions would focus on the following: Bend Bridge Pulse Protection; the Minimum Bypass Flows in the Sacramento River at Wilkins Slough; Fremont Weir Notch Protections (Big Notch Project); sediment monitoring, modeling and reintroduction; and fish monitoring and technical studies related to near-field effects.

3.15.7.2 Delta Conveyance Project

As described in the qualitative discussion, the DCP would function as a dual-conveyance SWP facility in conjunction with existing SWP Delta facilities through construction and operation of two new north Delta intakes with a combined diversion capacity of 6,000 cfs on the Sacramento River near the town of Hood. The north Delta diversion (NDD) would not alter operating criteria for existing facilities (e.g., upstream reservoirs or south Delta diversions), would be subject to existing and updated Delta water quality requirements (e.g., D-1641), and would not alter SWP/CVP water right permits (beyond the addition of new points of diversions). Existing south Delta diversions would be operated preferentially, with use of the NDD focused on periods of excess flow conditions in the Delta and to optimize salinity management in the summer and fall. Specific operational criteria focusing on minimizing potential effects on aquatic resources and listed fish would further govern NDD operations. Table 3-19, Table 3-20a, and Table 3-20b describe the proposed DCP operational criteria.

Table 3-18. Delta Conveyance Project Preliminary Proposed Operations Criteria (North Delta Diversion Operations)

Parameter	Delta Conveyance Project Criteria
Bypass Flow [a] (specifies bypass flow required to remain downstream of the north Delta intakes)	• October through November: Minimum flow of 7,000 cfs required in river after diverting at the north Delta intakes. • December through June: Once the pulse protection (see below) ends, north Delta diversions would not exceed Level 1 pumping unless specific criteria have been met to increase to Level 2 or Level 3. If those criteria are met, operations can proceed as defined in table 3-20. Allowable diversion would be the greater of the following options: low-level pumping or the diversion allowed by the bypass flow rules in the following table. • July through September: Minimum flow of 5,000 cfs required in river after diverting at the north Delta intakes.

Parameter	Delta Conveyance Project Criteria
Pulse Protection (October through June)	• Low-level pumping is allowed when river conditions are adequate during the pulse protection period. • Definition: Low-level pumping of up to 6% of total Sacramento River flow at Freeport such that diversions would not reduce bypass flow below 5,000 cfs. No more than a total of 900 cfs can be diverted by all the intakes combined. Low-level pumping can occur in October–November during a pulse protection event and in December–June as defined in the following table. In addition, north Delta diversion levels at all the intakes would be subject to a maximum approach velocity of 0.2 feet per second and a minimum sweeping velocity of 0.4 feet per second at the proposed fish screens. Velocity compliance would be informed by real-time hydrological data measured at the intake locations. • Pulse triggering, duration, and conclusion is determined based on the criteria defined in the following table. • If the initial pulse begins before December 1, the bypass flow criteria for the month (October and November) when the pulse occurred would take effect, following a pulse protection period. On December 1, the Level 1 rules defined in the following table apply unless a second pulse occurs.
Real-Time Operations	• The proposed operations criteria and tidal restoration mitigation are intended to minimize and fully mitigate the potential impacts of the NDD operations. The real time decision making specific to the NDD operations would be mainly associated with reviewing real-time abiotic and fish monitoring data and ensuring proposed weekly, daily and sub-daily operations are consistent with the permitted criteria and within the effects analyzed in the permits.
Adaptive Management	• The Operations Adaptive Management and Monitoring Program would be used to evaluate and consider changes in operational criteria based on information gained before and after the new facilities become operational. This program would be used to consider and address scientific uncertainty regarding the Delta ecosystem and to inform project operations.

cfs = cubic feet per second; NDD = north Delta diversion.

[a] Sacramento River flow upstream of the intakes to be measured flow at Freeport. Bypass flow is the 3-day tidally averaged Sacramento River flow computed as flow measured at Freeport minus the diversion rate. Sub-daily north Delta intakes' diversion operations would maintain fish screen approach and sweeping velocity criteria.

Table 3-19a. Proposed North Delta Diversion Bypass Flow and Pulse Protection Requirements

	Criteria
Pulse Protection	• Low-level pumping would be allowed when river conditions are adequate during the pulse protection period. Initiation of the pulse protection is defined by the following criteria: (1) Sacramento River daily average flow at Wilkins Slough increase by more than 45% within a 5-day period and (2) flow on the 5th day greater than 12,000 cfs. • The pulse protection continues until either (1) Sacramento River flow at Wilkins Slough returns to pre-pulse flow level (flow on first day of 5-day increase), or (2) Sacramento River flow at Wilkins Slough decreases for 5 consecutive days, or (3) Sacramento River flow at Wilkins Slough is greater than 20,000 cfs for 10 consecutive days. After pulse period has ended, operations would return to the bypass flow table (Table 3-20b). • If the initial pulse period begins before Dec 1, then any second pulse that may occur during December through June would receive the same protection, i.e., low-level pumping, resulting in up to two pulses which would receive this protection per water year.
Bypass Flow Criteria	• After initial pulse(s), allowable diversion would be subject to Level 1 bypass flow criteria (Table 3-20b) until 15 total days of bypass flows above 20,000 cfs occur. Then allowable diversion would be subject to the Level 2 bypass flow criteria until 30 total days of bypass flows above 20,000 cfs occur. Then allowable diversion would be subject to the Level 3 bypass flow criteria

Table 3-20b. North Delta Diversion Bypass Flow Criteria

Period		Level [a]	If Sacramento River flow		The bypass is…
			Is over…	But not over…	
December through April [b]		1	0 cfs	5,000 cfs	100% of the amount over 0 cfs
			5,000 cfs	15,000 cfs	Flows remaining after low-level pumping
			15,000 cfs	17,000 cfs	15,000 cfs plus 80% of the amount over 15,000 cfs
			17,000 cfs	20,000 cfs	16,600 cfs plus 60% of the amount over 17,000 cfs
			20,000 cfs	no limit	18,400 cfs plus 30% of the amount over 20,000 cfs
		2	0 cfs	5,000 cfs	100% of the amount over 0 cfs
			5,000 cfs	11,000 cfs	Flows remaining after low-level pumping
			11,000 cfs	15,000 cfs	11,000 cfs plus 60% of the amount over 11,000 cfs
			15,000 cfs	20,000 cfs	13,400 cfs plus 50% of the amount over 15,000 cfs
			20,000 cfs	no limit	15,900 cfs plus 20% of the amount over 20,000 cfs
		3	0 cfs	5,000 cfs	100% of the amount over 0 cfs
			5,000 cfs	9,000 cfs	Flows remaining after low-level pumping
			9,000 cfs	15,000 cfs	9,000 cfs plus 50% of the amount over 9,000 cfs
			15,000 cfs	20,000 cfs	12,000 cfs plus 20% of the amount over 15,000 cfs
			20,000 cfs	no limit	13,000 cfs plus 0% of the amount over 20,000 cfs
May [b]		1	0 cfs	5,000 cfs	100% of the amount over 0 cfs

Period		Level [a]	If Sacramento River flow		
			Is over...	But not over...	The bypass is...
			5,000 cfs	15,000 cfs	Flows remaining after low-level pumping
			15,000 cfs	17,000 cfs	15,000 cfs plus 70% of the amount over 15,000 cfs
			17,000 cfs	20,000 cfs	16,400 cfs plus 50% of the amount over 17,000 cfs
			20,000 cfs	no limit	17,900 cfs plus 20% of the amount over 20,000 cfs
		2	0 cfs	5,000 cfs	100% of the amount over 0 cfs
			5,000 cfs	11,000 cfs	Flows remaining after low-level pumping
			11,000 cfs	15,000 cfs	11,000 cfs plus 50% of the amount over 11,000 cfs
			15,000 cfs	20,000 cfs	13,000 cfs plus 35% of the amount over 15,000 cfs
			20,000 cfs	no limit	14,750 cfs plus 20% of the amount over 20,000 cfs
		3	0 cfs	5,000 cfs	100% of the amount over 0 cfs
			5,000 cfs	9,000 cfs	Flows remaining after low-level pumping
			9,000 cfs	15,000 cfs	9,000 cfs plus 40% of the amount over 9,000 cfs
			15,000 cfs	20,000 cfs	11,400 cfs plus 20% of the amount over 15,000 cfs
			20,000 cfs	no limit	12,400 cfs plus 0% of the amount over 20,000 cfs
June [b]		1	0 cfs	5,000 cfs	100% of the amount over 0 cfs
			5,000 cfs	15,000 cfs	Flows remaining after low-level pumping
			15,000 cfs	17,000 cfs	15,000 cfs plus 60% of the amount over 15,000 cfs
			17,000 cfs	20,000 cfs	16,200 cfs plus 40% of the amount over 17,000 cfs
			20,000 cfs	no limit	17,400 cfs plus 20% of the amount over 20,000 cfs
		2	0 cfs	5,000 cfs	100% of the amount over 0 cfs
			5,000 cfs	11,000 cfs	Flows remaining after low-level pumping
			11,000 cfs	15,000 cfs	11,000 cfs plus 40% of the amount over 11,000 cfs
			15,000 cfs	20,000 cfs	12,600 cfs plus 20% of the amount over 15,000 cfs
			20,000 cfs	no limit	13,600 cfs plus 20% of the amount over 20,000 cfs
		3	0 cfs	5,000 cfs	100% of the amount over 0 cfs
			5,000 cfs	9,000 cfs	Flows remaining after low-level pumping
			9,000 cfs	15,000 cfs	9,000 cfs plus 30% of the amount over 9,000 cfs
			15,000 cfs	20,000 cfs	10,800 cfs plus 20% of the amount over 15,000 cfs
			20,000 cfs	no limit	11,800 cfs plus 0% of the amount over 20,000 cfs
July through September		N/A	0 cfs	5,000 cfs	100% of the amount over 0 cfs
		N/A	5,000 cfs	No limit	A minimum of 5,000 cfs
October and November		N/A	0 cfs	7,000 cfs	100% of the amount over 0 cfs
		N/A	7,000 cfs	No limit	A minimum of 7,000 cfs

cfs = cubic feet per second.

[a] Level 1, Level 2 and Level 3 Bypass Flow Criteria do not apply July through November. Minimum Bypass Flow Criteria are applicable July through November as described in the table.
[b] Allowable diversion would be the greater of the low-level pumping or the diversion allowed by the following bypass flow rules.

3.15.8 Guiding Principles

To ensure that future authorizations of Sites and DCP are consistent with DWR and Reclamation's polices, guidelines, and procedures for its authorization, funding, and operation of water projects, Reclamation and DWR propose the following guiding principles to avoid, minimize and offset adverse effects of the proposed operations to listed species and critical habitat.

Guiding principles inform the upfront development of operational criteria and measures to avoid or minimize effects on listed species and critical habitat, including possible adjustment through adaptive management, that would be analyzed in the subsequent consultations. Current proposed operational criteria will be included and considered through quantitative assessments, as applicable. Potential operational refinements will be informed by the programmatic analysis (e.g., potential need for changes to the DCP Bypass Flow criteria), which will guide subsequent project-level consultations. Adaptive Management is intended to further address outstanding uncertainties up to, and throughout, the operations phase. Implementation goals are included to provide the necessary level of information to inform the programmatic section 7 analysis.

The following guiding principles are relevant to both projects, with some specific application to each project noted. Note that DCP would not create changes to baseline SWP or CVP upstream reservoir operational criteria. The DCP would be operated in a manner that does not impact either DWR or Reclamation's ability to operate upstream reservoirs to meet existing and future criteria and regulations. The guiding principles for regions upstream from the Delta are therefore specific only to Sites.

3.15.8.1 Upper Sacramento River (Sites Only)

Utilize the additional water supply provided by the Sites Project to address adverse effects of the CVP on salmonid and sturgeon habitat in the Sacramento River above the Red Bluff Pumping Plant by:

1. Optimizing the use of Reclamation's storage to facilitate the following:

    - Enhancing conservation of the cold water pool in Shasta Lake for use in managing temperatures in salmonid spawning habitat downstream of Keswick Dam particularly in dry water year types
    - Enhancing pulse flows envisioned in the Biological Assessment at appropriate times, particularly in years when natural pulse events are minimal, to stimulate migration of juvenile salmon downstream toward the Delta
    - Stabilizing flow to minimize or preclude losses of salmon redds due to flow fluctuations associated with management of Shasta Lake for fall storage

2. Implementing additional mitigation actions as necessary and appropriate to improve spawning and rearing habitat for anadromous fish in the Upper Sacramento River

3.15.8.2 Sacramento River from Red Bluff Pumping Plant to Knights Landing (Sites Only)

1. Implement actions necessary to minimize potential impacts to listed species exposed to diversion facilities

2. Implement pulse flow criteria to provide migrating anadromous fish an opportunity to migrate past the diversion locations with minimum exposure to diversions

3. Utilize best available science to establish flow levels necessary to provide migratory and rearing habitat to minimize effects on juvenile anadromous fish survival and facilitate their movement out of the river toward the delta and bays

4. Find opportunities to develop and/or restore additional side channel habitat to offset adverse effects on salmonid migratory and rearing habitat associated with diversions of flow to Sites Reservoir

3.15.8.3 Below Knights Landing and in the Delta

1. Operate projects consistent with existing and/or future regulatory requirements in the Delta.

2. Implement pulse flow criteria to provide migrating anadromous fish an opportunity to migrate past the diversion locations with minimum exposure to diversions and further minimize effects on through-Delta survival.

3. Utilize best available science to establish flow levels necessary to provide migratory and rearing habitat to minimize effects on juvenile anadromous fish survival and facilitate their movement out of the river toward the delta and bays.

4. Monitor and mitigate effects of diversions on habitat for Delta pelagic fish species through identification and implementation of opportunities to develop additional habitat (i.e., tidal habitat restoration) to improve productivity of those fish populations.

5. Monitor and mitigate effects of diversions on migrating anadromous species and their habitat through identification of opportunities to develop additional habitat (i.e., tidal and channel margin restoration) to improve productivity of those fish populations.

6. Protect habitat conditions supporting listed pelagic and anadromous species, mitigate potential flow related effects of Sites and DCP with habitat restoration developed in coordination with NMFS, USFWS, and CDFW to improve productivity of those fish populations.

Sites:

7. Cooperate in the monitoring of the Fremont Weir Big Notch Project to assess what effect, if any, diversions of flow to Sites Reservoir have on the effectiveness of the Big Notch Project in the entrainment of juvenile anadromous fish through the notch on the floodplain habitat in the Yolo Bypass and the passage of anadromous fish from the Yolo Bypass into the Sacramento River. If necessary, implement operational measures to avoid diminishing the performance of the Big Notch Project.

DCP:

8. Implement project operations and maintenance consistent with the proposed project description, as an integrated component of the SWP.

    a. Future consultation on Delta Conveyance Project Operations and Maintenance is envisioned to update and align elements of project description with conditions (e.g., regulatory, climate, status of species) in advance of operations of the north Delta diversions.

3.15.8.4 Suisun Bay, San Pablo, and San Francisco Bay

Cooperate with the fisheries resource agencies to monitor effects of diversions to the Sites Reservoir and DCP on the location of X2 and Delta outflow and, as appropriate, identify opportunities to offset adverse effects on critical habitat through appropriate mitigation measures or adaptive management actions.

3.15.9 Adaptive Management

Both Sites and DCP would have adaptive management programs that integrate with the Long-Term Operations adaptive management program and include these general principles:

1. Cooperate with and, as appropriate, participate in ongoing and planned habitat and population monitoring programs conducted by the resource agencies to ensure attainment of information pertinent to assessing the effects on endangered and threatened fish in the action area.

2. Design studies, in cooperation with resource agencies, to test modifications to operations that may be implemented to remedy or lessen unanticipated effects identified by the monitoring program.

3. Cooperate with the resource agencies to evaluate results of studies and determine whether changes in project operations are necessary and appropriate to address unanticipated adverse effects.

4. To the maximum extent possible/appropriate, integrate Sites and DCP adaptive management and monitoring with existing and proposed special studies, monitoring programs, technical teams, adaptive management and structured decision making processes associated with Long-Term-Operations.

5. Ongoing commitment to collaborative decision making processes consistent with the LTO adaptive management effort, including reliance on the LTO adaptive management wheel and structured decision making framework.

Project specific compliance efforts and monitoring would be the responsibility of the individual projects, but there would be a commitment to ongoing coordination and information sharing to support the broader monitoring and adaptive management processes.

The adaptive management program would document all activities associated with the planning phase of adaptive management and describe the process to be followed during the implementation and evaluation and response phases. Project objectives were taken into consideration in identifying where adaptive management would be most effective and applicable for the project. If the proposed project is approved, as appropriate, mitigation measures identified, such as implementation of the habitat creation and restoration actions, would integrate the concept of adaptive management in mitigation plan design, stand-alone site and/or resources specific adaptive management plans.

3.16 Other Activities

Other Activities include action components that are not specifically proposed by Reclamation but would not occur but for the action and that are reasonably certain to occur. These kinds of activities were previously referred to as "interrelated or interdependent" activities. Under the 2019 ESA regulations governing interagency coordination, a proposed action may cause other associated or connected actions, that are now called "other activities" to distinguish them from the proposed Federal action. These activities and their consequences must pass a two-part test of causation and foreseeability, meaning that they would not happen "but for" a Federally proposed action and that they are "reasonably certain to occur".

Portions of the Winter-Run Action Plan (WRAP) meet the two-part test of "but for" and "reasonably certain to occur" for the following reasons: First, the Winter-run Action Plan is a result of agency discussions with the Sacramento River Settlement Contractors for the operations of Shasta Reservoir. Without the new Shasta Operations framework, elements of the WRAP would not have been proposed, thus it meets the "but for" standard. Next, the elements of the WRAP are reasonably certain to occur because the parties to the WRAP have a long history, either individually or together, of advancing science, implementing habitat restoration, reintroducing fish to historic habitats, improving system infrastructure and adaptively managing hatcheries for long-term species needs.

3.16.1 Winter run action plan

3.16.1.1 Introduction

Sacramento River winter-run Chinook Salmon (winter-run) are an iconic species on the Sacramento River, beloved by a wide variety of communities with deep connections to the Sacramento Valley, including local landowners and residents, fishing groups, Native American tribes, and environmental NGOs. Historically, winter-run migrated into the upper Sacramento

River and spawned in high elevation tributaries with consistently cold water temperatures throughout the spring, summer, and fall. Prior to the construction of Shasta and Keswick dams, upper tributary dams and diversions above Shasta Dam and Battle Creek were constructed for power generation that limited access to parts of these high-elevation habitats. Construction of Shasta and Keswick dams and changes on Battle Creek further limited access through impaired passage, and only a single population of winter-run remains to spawn at much lower elevations on the Sacramento River below Keswick Dam. Currently, one remaining population of winter-run persists on the Sacramento River downstream of Shasta Dam and is exposed to a wide variety of stressors, including limitations of the availability of cold water release from Shasta Reservoir during the summer and fall spawning and rearing seasons. Winter-run have been selected as a "species in the spotlight" by NMFS to highlight their status among protected species with the greatest risk of extinction in the near future.

The challenges and threats faced by winter-run are diverse and complex. Some of the threats to the species include: changes in flow regime, climate variability, lost and degraded spawning habitat, removal/lack of access to rearing habitat (along the Sacramento River and in the Delta), recurring droughts and related impacts on reservoir storage and temperature management, thiamine deficiency, entrainment into water diversions, pathogens, predation by non-native species, and commercial and recreational fisheries. The extent of threats to winter-run is such that even under periods with good storage and favorable water temperatures, juvenile survival in the Sacramento River can be poor.

This Winter-run Action Plan has been developed collaboratively among representatives from Reclamation, NMFS, USFWS, DWR, CDFW, and the Sacramento River Settlement Contractors as an integrated plan to improve the survival and viability of winter-run that functions alongside planned operation of Shasta Reservoir. The intention is to implement the Winter-run Action Plan with other partners including Native American Tribes and NGOs.

3.16.1.2 Plan Priorities

Inspired by the list of threats above, this plan prioritizes implementation of six actions to reduce stressors to the species through a combination of science, fishery actions, infrastructure improvements, and improved habitat quality and access:

1. Thiamine Deficiency Complex Management
2. Reintroduction into Battle Creek and McCloud River
3. Early Life Stage Survival Science
4. Temperature Control Device Infrastructure Improvement at Shasta Dam
5. Modernization of the Livingston Stone National Fish Hatchery
6. Habitat restoration and facility improvements

These high priority actions are described in additional detail in Appendices 1-6. Each appendix provides a brief description of the action, a statement of purpose, an overview of past and current

work potential challenges for implementation, milestones, deliverables, permitting requirements, resource needs and commitments, and funding sources. To avoid duplicating effort and maximize efficiency, each of the appendices draws upon existing plans and implementation processes and identifies relevant areas of expertise. These priorities represent the current thinking on actions to reduce winter-run stressors. However, the Winter-run Action Plan is intended to adapt and address other stressors and threats that are identified in the future. The expectation is that collectively these actions will improve the status of winter-run over the next ten years.

3.16.1.3 Goals

The Winter-run Action Plan has been developed as an interdisciplinary and collaborative approach to addressing some of the priority threats to the species. The overarching goals of this plan are:

- Develop a structured and collaborative partnership that includes State and Federal agencies (Reclamation, NMFS, USFWS, DWR, and CDFW), the Sacramento River Settlement Contractors, non-governmental conservation and fishery groups, tribes, and universities;
- Elevate the prominence of priority actions, in addition to operations of Shasta Dam, that are expected to enhance our understanding of winter-run ecology, address key threats to the species, and move forward key infrastructure improvements to support the species;
- Increase abundance, improve population growth rates, maximize diversity, improve resiliency, and prevent extinction of winter-run through implementation of identified actions;
- Collaboratively assess funding needs to implement each of the priority actions, identify available funding sources, and pursue additional funding sources, as needed;
- Work together at a technical and project management level develop plans and implement each priority action, meet the established milestones, and provide timely deliverables.
- Identify resource needs to actively engage and make progress on each identified action according to milestones;
- Communicate early about permitting needs anticipated for each priority action and coordinate throughout permitting processes; and
- Consider links and potential co-benefits to other Chinook salmon runs, as well as other native fishes, during the process to plan and implement priority actions.

3.16.1.4 Partnerships and Governance

As described in Section 3.13, the agencies and partners will dedicate managers from each organization to participate on a Winter-run Action Plan policy team that will coordinate on plan implementation. The purpose of the policy team is to establish policy level coordination and processes for tracking plan goals, priorities, funding, resource needs, milestones and deliverables. The Winter-run Action Plan recognizes that some of the action plan components

may be part of separate planning processes and the policy team will evaluate opportunities to utilize existing efforts.

3.16.1.5 Winter-run Action Plan Policy Team

A Winter-run Action Plan Policy Team (WRAP Policy Team) consisting of Agency subdirectors and Partner managers will serve as the policy group for implementing the Winter-run Action Plan. The purpose of the WRAP Policy Team is to establish policy level coordination, leadership and direction for tracking plan goals, priorities related to the WRAP, coordination on resource needs, milestones and deliverables. The WRAP Policy Team will do the following:

1. Coordinate efforts for consultation and/or coordination agreements with Tribes, NGOs and Universities on WRAP action components

2. Identify opportunities to leverage the ongoing work of existing scientific, habitat and fishery management teams and programs

3. Review budget annually to identify potential gaps in funding

4. Track and meet established milestones and deliverables

5. Track and adjust, as necessary, plan goals and priorities

6. Identify where sub-teams require additional guidance so that managers may that provide that direction to their participating staff where appropriate

7. Participants are responsible SHOT members are aware of activities under the WRAP

8. Coordinate on alternative actions to evaluate

9. Provide quarterly updates to agency Directors and partner Principals and elevate matters as described under Collaborative Decision Making

3.16.1.6 Science Facilitation and Program Support

The WRAP Policy Team will work together to hire a program manager and an independent scientific facilitator to promote scientific collaboration and to address scientific debate and divergent scientific perspectives related to implementation of the WRAP. The WRAP program manager and scientific facilitator will have strong program management skills and a scientific background and/or understanding of the scientific matters related to water resource and protected species management.

The WRAP program manager with direction from the WRAP Policy Team will:

- Implement the WRAP
- Track milestones and deliverables
- Manage meeting schedules and logistics

- Coordinate WRAP-specific working groups
- Identify and track the implementation through existing working groups

The scientific facilitator will work with the WRAP Policy Team to:

- Develop processes to help streamline the development of research proposals and study plans
- Foster an environment of scientific coordination and knowledge exchange between researchers, agencies, and partners
- Organize and facilitate regular meetings, workshops, and seminars to promote scientific discussions and idea exchange
- Coordinate the development of briefing materials by researchers
- Identify and bridge gaps between scientific research and effective collaboration
- Summarize the status of discussions by researchers for the WRAP Policy Team
- Help the WRAP Policy Team coordinate with other science programs to leverage opportunities and avoid duplication
- Coordinate independent review of work products

3.17 References

Allison et al. 2021

Anderson 2022

Bedwell et al. 2021

Blankenship et al. 2020

California Department of Fish and Wildlife 2020

California Department of Fish and Game 1999

Del Rosario et al. 2013

California Department of Water Resources et al. 2020

Harvey et al. 2022

Hendrix et al. 2017

Horndeski 2022

Jennings and Hendrix 2020

Johnson et al. 2017

Lindley et. al. 2007

Martin 2017

Mount et al. 2016

National Marine Fisheries Service 2019

National Marine Fisheries Service 2014

Reclamation 2019

Smith et al. 2021

Souchon et al. 2008

State Water Resources Control Board 2000

U.S. Fish and Wildlife Service 2019

U.S. Fish and Wildlife Service 2018

U.S. Fish and Wildlife Service 2020

White and Low 2006

Windell et al. 2017

Programmatic Biological Opinion for the Reinitiation of Consultation on the Long-Term Operation of the Central Valley Project and State Water Project

Appendix B:

Summary of Selected Delta Literature

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Annotated Literature Review (Byrne, August 2018)……p. B-1 - B-6

Annotated Literature Review (Stuart, August 2018)……p. B-7 – B-16

Briefing on Six-Year Study (June 26, 2018)……p. B-17 – B-43

Selected Literature Review (Byrne, June 2024)……p. B-44 – B-47

Supplemental References…….. p. B-48

Annotated Lit Review I to E ratio_Byrne
August 2018

Selected Delta-related references relevant to water project-related effects in the south Delta

Prepared by Barb Byrne, NMFS California Central Valley Office
August 2018

Note: *Takeaway bullets and quotes have been selected as being most relevant to water operations in the South Delta and do not represent all key conclusions of the citations.*

1) California Department of Water Resources (2014). Stipulation Study: Steelhead Movement and Survival in the South Delta with Adaptive Management of Old and Middle River Flows. Prepared by David Delaney, Paul Bergman, Brad Cavallo, and Jenny Melgo (Cramer Fish Sciences) under the direction of Kevin Clark (DWR). February 2014.

http://baydeltaoffice.water.ca.gov/announcement/Final_Stipulation_Study_Report_7Feb2014.pdf

Takeaway Bullet: I believe that the conclusions drawn in this report are overbroad and only weakly caveated in the report. Analysis focused primarily on junctions with the San Joaquin River rather than on movement behavior within south Delta channels yet draws broad conclusions about effects of OMR in general.

Quote (p. ES-4): The statement "Under the OMR flow treatments tested in this study, there appeared to be little influence of OMR flows tested on steelhead tag travel times on the route-level and steelhead tag movement at the junctions and routes examined in this study (p. ES-3)" is technically correct but may be misleading to those not aware that the bulk of the analysis was in the mainstem San Joaquin River route and thus not necessarily applicable to the OMR corridor itself. Despite the limited range of OMR flows, small sample sizes, and focus on conditions in the mainstem San Joaquin River, the executive summary goes on to conclude (in my opinion, improperly) that "There is little evidence that altering OMR flows within the range that we examined in this study would alter fish behavior in a meaningful way".

Caveat: Limitations in the range of OMR conditions tested, changes to OMR within treatment periods, and relatively low power tests should be taken into consideration when interpreting the results of the stipulation study. The report reflects the outcomes of the statistical analysis of selected hypotheses at a few locations in the south Delta and, in my opinion, does not support broad conclusions about fish movement in the interior Delta in relation to OMR flows.

2) del Rosario, R. B., Y. J. Redler, K. Newman, P. L. Brandes, T. Sommer, K. Reece and R. Vincik (2013). "Migration Patterns of Juvenile Winter-run-sized Chinook Salmon (*Oncorhynchus tshawytscha*) through the Sacramento–San Joaquin Delta." San Francisco Estuary and Watershed Science 11(1).

https://escholarship.org/uc/item/36d88128

Takeaway Bullet: Winter-run Chinook salmon enter the Delta as early as October in some years and may make their way to the south Delta and be exposed to water-project-related hydrodynamic effects.

*Quote (from abstract): "*Winter-run passed Knights Landing…between October and April, with substantial variation in peak time of entry that was strongly associated with the first high flows

of the migration season. Specifically, the first day of flows of at least 400 m3 s-1 [~14,000 cfs] at Wilkins Slough (rkm 190) coincided with the first day that at least 5% of the annual total catch was observed at Knights Landing. … Differences in timing of cumulative catch at Knights Landing and Chipps Island indicate that apparent residence time in the Delta ranges from 41 to 117 days, with longer apparent residence times for juveniles arriving earlier at Knights Landing."

Caveat: Juvenile Chinook salmon were identified to race based on the length-at-date classification system, which has some uncertainty, but probably less so in the October and November time-frame when winter-run Chinook are essentially the only young-of-year Chinook run present in the system.

3) Hankin, D., D. Dauble, J. Pizzimenti, and P. Smith (2010). The Vernalis Adaptive Management Program (VAMP): Report of the 2010 Review Panel. Prepared for the Delta Science Program. May 13, 2010.

http://www.sjrg.org/peerreview/review_vamp_panel_report_final_051110.pdf

Takeaway Bullet: Complex hydrodynamics in the Delta, multiple stressors affecting salmonid survival, and a limited range of experimental conditions limit the inferences possible from the VAMP studies.

Quotes:

(p. 9) "Regarding export objectives, our feeling is that it makes sense during VAMP to continue limiting exports to some fraction of San Joaquin River flow at Vernalis so that the entire flow of the San Joaquin River is not diverted and so that reverse flows, if they occur, are not large. We cannot, however, offer any guidance as to what the Vernalis flow/export ratio should be…However, we do not believe that migration through Old River and subsequent salvage trucking and release is a desirable route for downstream migrating smolts. To the maximum extent possible, migration through the mainstem San Joaquin channel should be encouraged."

(p. 3) "The complexities of Delta hydraulics in a strongly tidal environment, and high and likely highly variable impacts of predation, appear to affect survival rates more than the river flow, by itself, and greatly complicate the assessment of effects of flow on survival rates of smolts. And overlaying these complexities is an apparent strong trend toward reduced survival rates at all flows over the past ten years in the Delta. Nevertheless, the evidence supports a conclusion that increased flows generally have a positive effect on survival and that it is desirable, to the extent feasible, to reduce or eliminate downstream passage through the Old River channel. The panel understands, of course, that flow, exports, and the placement of barriers in the Delta are the variables affecting survival that are most easily managed."

Caveat: See takeaway bullet.

4) Johnson, R. C., S. Windell, P. L. Brandes, J. L. Conrad, J. Ferguson, P. A. L. Goertler, B. N. Harvey, J. Heublein, J. A. Israel, D. W. Kratville, J. E. Kirsch, R. W. Perry, J. Pisciotto, W. R. Poytress, K. Reece and B. G. Swart (2017). "Science Advancements Key to Increasing Management Value of Life Stage Monitoring Networks for Endangered Sacramento River Winter-Run Chinook Salmon in California." San Francisco Estuary and Watershed Science 15(3).

https://doi.org/10.15447/sfews.2017v15iss3art1

Takeaway Bullet: Our ability to evaluate risks to listed salmonids at finer spatial and temporal scales may require changes to our monitoring.

*Quote (from abstract): "*We concluded that the current monitoring network was insufficient to diagnose when (life stage) and where (geographic domain) chronic or episodic reductions in SRWRC cohorts occur, precluding within- and among-year comparisons. …We identified six system-wide recommended actions to strengthen the value of data generated from the existing monitoring network to assess resource management actions: (1) incorporate genetic run identification; (2) develop juvenile abundance estimates; (3) collect data for life history diversity metrics at multiple life stages; (4) expand and enhance real-time fish survival and movement monitoring; (5) collect fish condition data; and (6) provide timely public access to monitoring data in open data formats."

Caveat: Most of the recommended actions will require additional resources for implementation.

5) Monismith, S., M. Fabrizio, M. Healey, J. Nestler, K. Rose and J. Van Sickle (2014). Workshop on the Interior Delta Flows and Related Stressors: Panel Summary Report. Prepared for the Delta Science Program. July 2014.

http://deltacouncil.ca.gov/sites/default/files/documents/files/Int-Flows-and-Related-Stressors-Report.pdf

Takeaway Bullet: The migration of both Chinook fry and smolts may be disrupted by interior Delta flow fields; steelhead may also be affected but less so given their larger size.

Quotes:

(p. 37): "Chinook salmon fry are not strong swimmers and typically hold in shallow embayments or use structures to keep from being carried along by the prevailing current. Kjelson et al. (1982) noted that beach seine catches of Chinook salmon fry in the Delta dropped significantly at night, suggesting fry were moving away from shallow nearshore areas at night. Larger fry were captured further offshore, near the surface during the day but broadly distributed in the water column at night. If the fry move away from shore at night they would lose visual and tactile clues to their position and would likely simply be carried by the currents. This is characteristic of salmon fry (and smolt) behavior during downstream migration, which occurs primarily at night due to passive drift, but may be less functional in the tidal Delta. In the historic Delta, with its extensive marshes and many blind ending dendritic channels, simply drifting at night might not

take the fry very far. In the modern Delta, however, with open trapezoidal channels and high-velocity tidal currents, fry might be carried a considerable distance in the Delta and find themselves in unfavorable habitats when light returns."

(p. 39-40): "Although Chinook salmon smolts do not go with the flow strictly in proportion to discharge they do make use of flow during migration. This raises the possibility that they could be confused by reverse flows in OMR. Because of the reverse flows in OMR when exports are large, the smolts are likely to receive mixed signals from tidal flux as water could be moving toward the pumps on both flood and ebb tides depending on the operation of the gates to Clifton Court Forebay (CCF). In this case, smolts may find themselves virtually trapped within OMR over several tidal cycles and potentially attracted into CCF because of inappropriate signals from water chemistry and flow. Since conveyance through the Delta is designed to ensure high quality of export waters (i.e., low salinity) it may be that near the pumps there is insufficient salinity signal on the tidal flow to direct the smolts and they simply go with the flow toward the pumps expecting that it is carrying them downstream. Salmon also make use of compass orientation during their migrations although the extent to which they might use this ability in the Delta is uncertain. It is possible that they might recognize that moving southward in OMR was inappropriate but whether they would be motivated to make some kind of corrective action is unknown."

(p. 44): "It appears that steelhead, which are larger than Chinook salmon smolts, are less affected by interior Delta flow fields, move through the Delta more quickly than Chinook salmon and experience greater survival. Nevertheless, steelhead are entrained into CCF and into the export pumps suggesting that some of the cues and clues they receive during their migration through the Delta lead them in the wrong direction."

Caveat: The report notes that "*(p. 74)* the vast majority of inferences about the effects of flows in the Delta on listed species are based on correlation analyses. Although correlation analysis is a useful first step when searching for relationships among variables, it often tells little or nothing about cause and effect" and "*(p. 75)* Fish in the Delta are subject to a large number of stressors and untangling the independent effects of these stressors has proven very difficult."

6) Perry, R. W., R. A. Buchanan, P. L. Brandes, J. R. Burau and J. A. Israel (2016). "Anadromous Salmonids in the Delta: New Science 2006–2016." San Francisco Estuary and Watershed Science 14(2).

http://dx.doi.org/10.15447/sfews.2016v14iss2art7

Takeaway Bullet: This paper covers a lot of topics relevant to the draft proposed Initial Action so have not selected a single takeaway bullet. My selected quote emphasizes the point that more is known about the behavior of salmonid smolts compared to salmonid parr or fry.

Quotes:

(from abstract) "Although much has been learned, knowledge gaps remain about how very small juvenile salmon (fry and parr) use the Delta. Understanding how all life stages of juvenile

salmon grow, rear, and survive in the Delta is critical for devising management strategies that support a diversity of life history strategies."

Caveat: None specific to this paper; each of the studies summarized in this paper have their own associated caveats.

7) Salmonid Scoping Team (2017). Effects of Water Project Operations on Juvenile Salmonid Migration and Survival in the South Delta. Volume 1: Findings and Recommendations. January 2017.

http://www.westcoast.fisheries.noaa.gov/central_valley/water_operations/OCAPreports.html

Takeaway Bullet: See selected quotes for key takeaways.

Quotes:

(p. ES-6): "Water export operations contribute to salmonid mortality in the Delta via direct mortality at the facilities, but direct mortality does not account for the majority of the mortality experienced in the Delta; the mechanism and magnitude of indirect effects of water project operations on Delta mortality outside the facilities is uncertain."

(p. ES-6): "The evidence of a relationship between exports and through-Delta survival is inconclusive; the key findings presented in this table are supported by medium or high basis of knowledge, but our basis of knowledge on the relationship between exports and through-Delta survival is low (Appendix E, Section E.6.2.1)."

(p. ES-7): "It is unknown whether equivocal findings regarding the existence and nature of a relationship between exports and through-Delta survival is due to the lack of a relationship, the concurrent and confounding influence of other variables, or the effect of low overall survival in recent years. These data gaps support a recommendation for further analysis of available data, as well as additional investigations to test hypotheses regarding export effects on migration and survival of Sacramento and San Joaquin River origin salmonids migrating through the Delta."

(p. ES-10): "Uncertainty in the relationships between I:E, E:I, and OMR reverse flows and through-Delta survival may be caused by the concurrent and confounding influence of correlated variables, overall low survival, and low power to detect differences (Appendix E, Section E.2.3)."

(p. ES-10):

"• I:E: The relationship between Delta survival of San Joaquin River Chinook salmon and I:E is variable but generally positive for lower I:E values (e.g., I:E less than 3) (Appendix E, Section E.11, Figure E.11-1). Results of these studies are confounded by the use of flow ratios since the same I:E ratio can represent different absolute flow and export rates. These results are further confounded by installation and operations of various South Delta barriers. Data are available from only two years of AT studies using steelhead (Appendix E, Section E.11-4).

• Exports: There was a weak positive association between the through-Delta survival of San Joaquin Chinook salmon and combined exports using the CWT data set, but comparisons are complicated by the correlation between exports and San Joaquin River inflow (Appendix E, Section E.6.2.1)."

Caveat (p. ES-12): "Current understanding of juvenile salmon and steelhead survival in the Delta is constrained by a variety of factors…" [See the list of "Constraints on Understanding" on pages ES-12 to ES-13]

8) Salmonid Scoping Team (2017). Effects of Water Project Operations on Juvenile Salmonid Migration and Survival in the South Delta. Volume 2: Responses to Management Questions. January 2017.

http://www.westcoast.fisheries.noaa.gov/central_valley/water_operations/OCAPreports.html

Takeaway Bullet: If the in-season risk assessments in the draft proposed Initial Actions result in a start to OMR management later than January 1, ESA-listed salmonids (winter-run in most years, spring-run in many years, and steelhead in some years) may not have protection equal to that provided by implementation of the 2009 NMFS BiOp.

Quote (p. ES-2): "Although not capturing the seasonal variation in juvenile movement, the January 1 onset of Old and Middle rivers (OMR) reverse flow management coincides with the presence of winter-run Chinook salmon in most years, spring-run Chinook salmon in many years, and steelhead in some years (Figures 4-1, 4-2, 4-3, and 4-4 in Section 4). If OMR reverse flow management were initiated based on first detection in the Delta rather than a fixed date, OMR reverse flow management would often begin earlier than January 1 for the protection of winter-run or spring-run Chinook salmon, and later than January 1 for the protection of steelhead. The January 1 trigger date provides a general approximation of a date by which juvenile winter-run Chinook have likely entered the Delta and, based on its simplicity for triggering management actions, has utility."

Caveat: See some technical disagreements about OMR management described on pages ES-2 to ES-3

1). **Vogel, D. 2002. Juvenile Chinook salmon radio-telemetry study in the Southern Sacramento-San Joaquin Delta, December 2000-January 2001.**

Take Home Bullet: Fish released at Woodward Island on Old River during higher export conditions (~8,000 to 11,000 cfs) encountered more negative ambient flow conditions in Old River and consistently moved farther south towards the Projects than fish released under low export conditions (2,000 to 4,700 cfs) with more positive net flow conditions in Old River.

Quote: "The single most evident difference in results between the two medium export experiments and the two low export experiments was the behavior of radio-tagged fish during the first day after release. Radio-tagged salmon in releases 1 and 2 (medium export) experienced minimal or no positive (downstream) flow on the first day whereas fish releases 3 and 4 (low export) experienced long periods of high positive flow. The medium export levels dampened out or nearly eliminated any positive or north flows in Old River. Most fish in releases 1 and 2 exhibited a rapid, southerly migration responding to the high negative flow conditions. In contrast, most fish in releases 3 and 4 moved back and forth (i.e. north and south in Old River in response to the ebb (positive) and flood (negative) flow conditions and remained detectable in Old River for a longer duration than those fish in releases 1 and 2."(Page 20)

Caveat: Final disposition of the radio tagged fish was difficult to discern using mobile tracking only during the day. Night time tracking was not feasible in this study. However, if fish were last detected in close proximity to the Projects, it was assumed that they were entrained either into Clifton Court Forebay or the CVP if they were not detected the next morning.

2) **Vogel, D. 2005. The effects of Delta hydrodynamics conditions on San Joaquin River juvenile salmon.**

Take Home Bullets:
1) The overwhelming effects of tidal flows and site specific hydrodynamic conditions at critical channel junctions are likely masking any relationships between survival based solely on Vernalis flows or export levels.
2) Environmental noise overwhelms any survival relationship signal and makes detection of a statistical relationship between physical parameters nearly impossible without increasing sample size or replicates (i.e. low recovery of CWT fish in the VAMP experiments).
3) Fish moved into junctions in proportions that were not anticipated based on flow splits, and that once fish had left the mainstem San Joaquin River into one of the South Delta distributaries, they typically did not re-enter the mainstem at a later date. The lowest entrainment of fish occurred when the net reverse flows and SWP and CVP exports were lowest.

Quote:

"The "zone of influence" delineating exactly where in the central and south Delta that exports have an overriding influence on salmon "entrainment" into the south Delta is presently unknown and would vary depending on export levels. The smolt telemetry study conducted in December 2000-January 2001 provided empirical evidence that the zone of influence extends at least as far north as the northwestern tip of Woodward Island, a distance of approximately nine river miles

north of the CC gates. The two smolt telemetry studies conducted in the mainstem San Joaquin River suggest that the zone of influence is probably much further north (e.g., Turner Cut and Columbia Cut) but the unknown specific regions would depend on many complex and interrelated hydrodynamic variables (e.g., exports, river flows, tides, tidal prisms, localized channel velocities, channel geometry, etc.) combined with fish behavior." (Page 11).

"Also it appears that some smolts, once they move into those south channels do not re-emerge back into the San Joaquin to continue normal migration toward salt water. This latter phenomenon is also not understood. Because of net reverse flows that fish encounter in specific channels south of the San Joaquin River, outmigrating salmon apparently have difficulty re-emerging back into the mainstem. The magnitude of the net reverse flows increases with closer proximity to the south Delta export facilities. Once salmon enter this region of the Delta, the fish likely experience high mortality rates caused by predation and entrainment into unscreened diversions and the export facilities. Some fish are known to be survive the migration all the way to the export facilities, are salvaged, and transported out to the western Delta or San Francisco Bay. However, the proportion of total numbers of salmon unsuccessfully navigating these interior Delta channels is unknown." (Pages 15-16)

Caveats: The report utilizes data from both CWT fish and radio-tagged fish to draw conclusions. It was pointed out that the CWT studies were of low resolution due to the low recovery rates at the terminal sampling location and the lack of internal sampling locations – it could only draw conclusions from point A (release site) to point B (terminal sampling site) with no information regarding what happened in between those two points. The radio tag telemetry studies had higher resolution due to active mobile tracking, but also had issues with low sample numbers and difficulty of tracking fish during the night. However, radio telemetry provided much greater information regarding the movements of fish within the overall migratory route. This initial data reflects the trends of information gained in later studies using acoustic tag technology.

3) San Joaquin River Group Authority 2007. 2006 Annual Technical Report.

Take Home Bullets:

1) Data reinforces the benefit of installing a temporary barrier at the head of Old River which provides protection to juvenile salmon migrating out of the SJ River basin and prevents them from entering the Old River channel.
2) San Joaquin River flows, and flows relative to exports, between April 15 and June 15 was positively correlated to adult escapement in the San Joaquin River basin 2.5 years later. Both relationships were statistically significant ($p<0.01$) with the ratio of flow to exports accounting for slightly more of the variability in escapement than flow alone ($r^2 = 0.58$, vs. $r^2 = 0.42$).
3) With HORB in place, increasing Vernalis flows increased survival of upstream release groups relative to downstream release groups and was statistically significant ($p< 0.01$).
4) Without the HORB in place, there was no clear relationship between the survival rates as measured by differential recovery rates/ combined differential recovery rates for upstream versus downstream releases and flow using the Chipps Island, Antioch, and ocean recoveries for the Mossdale and Durham Ferry releases relative to the Jersey Point releases. There was more variability associated with smolt survival at any given flow without the HORB since the

flow and proportion of fish moving into the Old River channel varies more without the HORB.

5) Flows alone explained survival better than flows relative to exports alone, but the flow/export ratio did increase the fit of the survival correlation and reduced variability in the model.
6) Total absolute prediction error is about 15% less using the model that incorporated the flow/export variable, indicating that it better predicts the survival data than the model using flow alone.
7) Increasing temperature in the San Joaquin River appears to be a confounding factor in determining the role of exports and flow, particularly in late season releases.

Quotes:

"One potential explanation for these results is that the level of exports were low and did not vary enough during these experiments to provide sufficient differences to be detected in our measurements of smolt survival. Exports ranged between 1,450 and 2,350 cfs during these experiments which is much lower than those incorporated into the adult escapement relationships. Another complication is that exports and San Joaquin River flows were correlated with higher exports observed during times of higher flows (Figure 5-16). It is also likely the relationship of exports to smolt survival is different with the HORB in place than when it is absent…..the HORB was not installed during the majority of the years incorporated into the adult relationships." (page 60)

"These adult relationships would indicate that as you increase flows and decrease exports relative to flows there should be corresponding increases in smolt survival and adult escapement 2 ½ years later." (page 63).

"It is not surprising that there is some uncertainty and noise in these relationships because escapement data does not incorporate the varying age classes within annual escapement, the impact of declining ocean harvest in recent years, and the imprecision in the escapement estimates." (page 63).

Caveats:

As indicated in the report, the lack of recoveries of fish at the terminal sampling points decreases the sensitivity of the study to detect relationships between the different parameters of interest. Statistically significant relationships are typically only seen for "strong" relationships where the signal of the relationship can be detected over the "noise" in the environment, subtle relationships are typically not seen as statistically significant due to the signal being overwhelmed by the environmental noise. Likewise, the VAMP studies did not test all of the flow and export combinations that were initially proposed, thus the ability to discriminate the nature of relationships between the parameters of interest are diminished due to an over representation of only a few parameter pairings, and a lack of pairings at the extremes of the parameter pairings, which would allow for better resolution of parameter effects and relationships.

4) **Newman, K.B., 2008, An Evaluation of Four Sacramento-San Joaquin River Delta juvenile salmon survival studies.**

Take Home Bullets:
1) Newman used Bayesian Hierarchical models (BHMs) to reanalyze data from the four different studies (DCC gate operations, Interior Delta survival, Delta Action 8, and VAMP). The BHMs accounted for unequal sampling variation and between release variations. Recoveries from multiple locations were analyzed in combination. The BHM framework is more statistically efficient and coherent compared to previous analyses.

2) Results from the reanalysis of the Delta Action 8 studies indicate that there was a negative association between export volume and relative survival; that is a 98% chance that as exports increased, relative survival decreased. Environmental variation in the relative survival was very large, however, and a paired low export release could have a high probability of a lower relative survival than a paired high export release due to differences in the environmental parameters and their influence on the relative survival of the paired release.

3) For the VAMP studies, (a) The expected probability of surviving to Jersey Point was consistently larger for fish staying in the San Joaquin River (i.e., passing Dos Reis) than fish entering Old River, but the magnitude of the difference varied between models some-what; (b) thus if the HORB effectively keeps fish from entering Old River, survival of out-migrants should increase; (c) there was a positive association between flow at Dos Reis and subsequent survival from Dos Reis and Jersey Point release sites, and if data from 2003 and later were eliminated from analysis the strength of the association increased and a positive association between flow in Old River and survival in Old River appeared; (d) associations between water export levels and survival probabilities were weak to negligible given the magnitude of environmental noise.

4) In general, data limitations inherent to release-recovery data, i.e., that only one capture is possible, relatively low capture probabilities, relatively high environmental variation, and in the case of VAMP the lack of balance in the release strategy, affect the accuracy of estimates of effects on survival.

5) Given the apparently high environmental variation, it may take many replications of temporally paired releases to more accurately quantify the effects of DCC gate position, exports, flow, and HORB on survival.

Quotes:

1) (For the Delta Action 8 Studies) “The key parameter is β_1 (the coefficient for exports in the logistic regression of θ; see equation 29). It had a 98% probability of being negative, indicative of a negative association between the relative survival of Georgiana Slough and Ryde releases (θ) and exports.” And “The plot shows the decline in mean θ as exports increases (when exports are at 2000 cfs, mean θ is 0.62, and when exports are at 10,000 cfs, mean θ is 0.31).” (Page 59)

2) (For the VAMP Studies) “The expected survival probability down Old River was always less than the survival down the San Joaquin River. Different models yielded somewhat different

expected values, but the survival down Old River was generally, if not always, lower than those for the San Joaquin." (Page 62).

3) "Covariate values affect precision, too. For the DA 8 studies, increasing the number of observations at the "extremes" of export levels will increase the precision in the estimate of the slope parameter (β_1 in Equation 29). Similarly, for the VAMP studies, increasing the number of observations at the "extremes" of flow and exports will increase the precision of the related (partial) slope parameters (Equations 43-46)." (Page 68).

4) "However, with HORB in, survival of releases made above the head of Old River was significantly related to flow, but the relationship with exports and flow/exports was inconsistent and sometimes paradoxical (e.g., exports were positively associated with survival, weakly statistically significant using Antioch and Chipps Island recoveries and insignificant using ocean recoveries). The fact that the presence of the HORB affected the relationships with flow suggests an interaction between flow and HORB." (Page 75).

5) "For the various models fitted, there were two in-common conclusions: (1) flow is positively associated with the probability of surviving from Dos Reis to Jersey Point and (2) the survival probability for that reach is generally greater than the survival probability for fish traveling down Old River. Assuming that the HORB effectively keeps out-migrating salmon from entering Old River, the second conclusion implies that the HORB can increase salmon survival. For fish that do enter Old River, there was some evidence that flow in Old River was positively associated with survival between Old River and Jersey Point, but the evidence was not as consistently strong as for the Dos Reis to Jersey Point reach. There was little evidence for any association between exports and survival, and what evidence there was pointed towards a somewhat surprising positive association with exports." (Page 75-76).

Caveats:

There is an apparent paradoxical relationship for export effects and survival – it is a negative relationship for salmon coming from the Sacramento River side of the Delta as depicted in the results for the Delta Action 8 studies, yet has either a negligible or slightly positive relationship for fish migrating out of the San Joaquin River basin. This may be an artifact of the relationship between higher flows in the San Joaquin River fostering higher survival for SJ basin fish, and the relationship between high flows in the SJ River and increased export levels at the Projects. It is possible that the higher survival is due mainly to higher flows, and not do to a positive relationship with exports.

5) **Newman and Brandes, 2010. Hierarchical modeling of juvenile Chinook salmon survival as a function of Sacramento-San Joaquin Delta water exports.**

Take Home Bullets:
1) Study used temporally paired releases of LFR Chinook salmon in the Delta: Sacramento River at Ryde and within Georgiana Slough, downstream from its junction with the Sacramento River (15 paired releases over the period between 1993 and 2005).

2) Reanalysis of earlier work (Brandes and McLain, 2001), this time only using the LFR Chinook salmon releases; and using Bayesian hierarchical modeling for the statistical analysis.

3) Analysis looked for the relationship of exports by the south Delta Projects on survival of fish released at the different release points using Chipps Island trawl recoveries (recaptured relatively immediately after release) and the ocean and inland recovery data of study fish over the next 2-4 years.

4) Analysis of the data found a consistently negative relationship between the level of exports and survival of fish released in Georgiana Slough (which are presumed to enter the central and south Delta waterways where the effects of the exports are manifested). There is an 86 – 92% probability that the relationship is negative based on the Bayesian modeling.

5) A consistently greater fraction of fish that were released in Georgiana Slough were recovered in salvage at the Projects compared to those fish released at the Ryde location, and this fraction increased with greater export levels.

6) The analysis of this data also pointed out how the low signal to environmental noise ratio diminishes the sensitivity of the analysis to detect the relationships between the parameters of interest and find statistically significant relationships. There was very little difference between models that had exports and those which did not.

Quotes:

1) "The recovery fractions for the Georgiana Slough releases were consistently less than those for the Ryde releases, with the exception of the fraction recovered at the fish facilities."

2) "(A)t the fish facilities, Georgiana Slough releases were about 16 times more likely to be recovered. Also, the fraction of fish facility recoveries from the Georgiana Slough releases tended to increase (from about 0.001 to 0.025) as exports increased from 2,000 cfs to 10,000 cfs (1 cfs = 0.028 m3/s), although there was considerable variability at any given level of exports (Figure 3). This suggested a higher probability of ending up at the pumps with greater exports."

3) "Regarding the relationship between relative survival and export level, the point estimates of the effects of exports were consistently negative and for the BHMs the probability that the effects are negative was 86–92%. However, as a result of the low signal-to-noise ratio, the DIC values and posterior model probabilities indicate that the predictive ability of models without exports is equivalent to that of models with exports."

Caveats:

As with other studies using CWT fish, the low absolute number of fish recovered in monitoring efforts impacts the ability of the study to detect relationships between the parameters of interest. These studies are limited by the low signal to environmental noise ratios that are typically present in these types of studies. Improving the sensitivity of these studies requires either using better methods (i.e. better/newer technology) or increasing the sample sizes/replications

substantially to detect relationships, which would likely require many more years of studies to have a sufficient number of replicates to increase the sensitivity of the study. The failure to reach a statistically significant relationship does not automatically exclude that a true relationship exists between the parameters, it could very likely be obscured by the low signal to noise ratio.

6) Dauble et al. 2010. The Vernalis Adaptive Management Program (VAMP): Report of the 2010 Review Panel.

Take Home Bullets:
1) Simple solutions are unlikely to consistently enhance survival of salmon smolts through the Delta over time. The Delta has complex hydraulics in a strongly tidal environment, and high and likely variable predation effects, that are likely to affect survival rates more than river flow by itself.

2) The panel, however, found that increasing flows in the San Joaquin generally has a positive effect on smolt survival through the Delta and that reducing or eliminating downstream passage through the Old River channel was desirable. The Panel also understood that flow, exports, and the placement of a barrier at the Head of Old River were the variables affecting survival that were most easily manipulated and managed.

3) Apparent downstream migration survival of juvenile Chinook salmon was very poor during 2005 and 2006 even though Vernalis flows were unusually high (10,390 cfs and 26,020 cfs, respectively). These recent data serve as an important indicator that high Vernalis flow, by itself, cannot guarantee strong downstream migrant survival.

4) The panel observed that there is an apparent decline in smolt survival over the 10 year period between 2000 and 2010 at several different levels of San Joaquin River flows ranging from very low to high and that this may be the "new" future smolt survival environment.

5) The panel found that although exports did not have a detectable statistical relationship with survival, that the study results should still be considered inconclusive due to the abbreviated range of conditions under which the data was collected.

6) The panel found that both the empirical evidence and logical inference support the conclusion that installation of a barrier at the head of Old River improves survival of downstream migrating Chinook salmon smolts.

Quotes:

1) "(R)ecent data serve as an important indicator that high Vernalis flow, by *itself*, cannot guarantee strong downstream migrant survival."

2) "analyses (summarized in SRJTC, 2008) and Bayesian hierarchical modeling (BHM) analyses (Newman, 2008) were unable to detect any statistical associations between exports and smolt survival through the Delta using the VAMP CWT study data. For a number of reasons, however, we do not believe these findings should be interpreted as meaning that exports, especially at high

levels, have no effect on survival rates. CWT study data were not collected over an adequate range of export levels to achieve enough statistical power to identify an export effect."

3) "The five years (2000-2004) of actual VAMP CWT studies done with a HORB in place investigated a range of exports only between 1,450 and 2,250 cfs. We believe this is much too narrow a range in exports to allow detection of a statistically significant export-survival relationship for the San Joaquin River."

4) "We believe that any "Export" effect must be masked by this "Old River" effect, and that the lower survival observed for the Old River route is at least partially attributable to export effects, both direct and indirect. One reason we believe this is that while predation might naturally be higher along Old River, the export facilities themselves seem to attract additional predators to the south Delta. A second reason is that the data show that the numbers of CWT study smolts detected in the salvage at the fish facilities are always higher for releases on upper Old River versus Dos Reis. Thus there are clear differences in direct entrainment losses between the two routes. Finally, if a fish traveling the Old River route does successfully navigate past the fish facilities during periods of high exports, it is then subjected to the reverse net flows, caused by exports, in the reaches of Old and Middle Rivers north of the facilities. It is difficult to imagine that migrating salmon smolts, cueing mostly on flow direction, will not have greater difficulty navigating to the north through these reaches to San Francisco Bay in a direction that might appear as "upstream" to their senses. Losses of smolts due to altered hydrodynamic conditions or migration cues in the Delta related to exports are referred to as "indirect" losses or mortality."

5) "Although lack of an ability to detect an "Export effect" on survival rates can be in large part attributed to lack of variation in recent export flows, we are reluctant to recommend substantial increases in export flows so as to improve the ability to detect an export effect. Among other things, the potential negative consequences of increased exports during downstream migration of juvenile Chinook salmon (and also on survival of juvenile delta smelt) probably outweigh any possible increase in knowledge."

Caveats:

These comments and findings are the results of deliberations by an independent science review panel convened to assess the VAMP studies.

7) **High level Summary of the Six-year Steelhead Study for the years 2011-2015**

- Four years of the total six years of studies have been written up as either final or draft reports
    - Final Reports available for 2011-2015
    - Finals for years 2014 and 2015 sent July 30, 2018
- Studies released acoustically tagged hatchery steelhead into the San Joaquin River at Durham Ferry and tracked them through the Delta system using multiple releases and multiple acoustic receiver locations throughout the lower San Joaquin River and Delta.
    - 2011 – Five releases, total of 2,196 fish tagged and released at Durham Ferry from late March through mid-June.

  - 2012 – Three release, total of 1,435 fish tagged and released at Durham Ferry from early April through mid-May.
  - 2013 – Three releases, total of 1,425 fish tagged and released at Durham Ferry from early March through early May.
  - 2014 – Three release, total of 1,432 fish tagged and released at Durham Ferry from late March through late May.
  - 2015 – Three releases, total of 1,427 fish tagged and released at Durham Ferry from early March to late April.
- Studies occurred during a wet year (2011) and four dry/critically dry years (2012-2015; the first four years of the 5-year drought).
  - Flows during the wet year (2011) were typically above 10,000 cfs at Vernalis, and peaked at approximately 29,000 cfs.
  - Flows during 2012 through 2015 were considerably less, never exceeding 5,000 cfs at Vernalis, and typically less than 2,500 cfs for most of the period of interest.
  - The HOR barrier was installed during 2012, 2014, and 2015. In 2014 the HOR barrier went in after the first release of fish occurred. With the barrier in, few fish were entrained into the Old River route at the junction of Old River and the San Joaquin River. In 2015, the barrier went in shortly after the second release of fish in late March, being present for the passage of approximately 35% of the released fish past the bifurcation of Old River and the mainstem San Joaquin River.
- During the wet year (2011) survival was better than the drought years (2012-2015) for both the San Joaquin River route (S_A) and the Old River route (S_B), as well as total survival (S_{total}) through the system.
  - Absolute survival through the San Joaquin River route was better than the Old River route in 4 of the 5 study years (2011, 2012, 2014, and 2015).
  - Survival through the sub-routes; south Delta and middle Delta (S_{SD} and S_{MD}), were variable and release group dependent. Clear distinctions between the Old River and San Joaquin River routes were not consistent.
- The presence of the HOR barrier was important in determining the proportion of fish entering Old River in relation to those remaining in the San Joaquin River route.
  - During low flow years, when the barrier was out, (2013, first release in 2014, first and second release in 2015), and fish were released into the system at Durham Ferry, higher numbers of fish entered the Old River route at the HOR junction. This appears to be a function of river stage, tides, and shunting of flow into the Old River channel.
  - When flows were high (2011) the distribution of fish into Old River and the San Joaquin were nearly equal.
- Water temperatures were elevated in 4 out of the 5 study years (2012-2015) during the fish releases.
  - Waters temperatures (as measured at Mossdale) were consistently lower in 2011 compared to 2012-2015 during fish releases.
  - Water temperatures in 2012 were consistently above 18ºC for the second and third releases. Water temperatures following the first release were between 15 and 18ºC.
  - Water temperatures in 2013 were slightly below 15ºC during the first release, but were above 15ºC during the second and third releases.

  - Water temperatures in 2014 were between 15 and 18ºC during the three releases, with spikes following the first and third releases.
  - Water temperatures in 2015 were between 16 and 20ºC for the first release in early March, between 17 and 20 ºC for the late March release, and 19 and 23ºC for the late April release.
- Survival, as measured per kilometer travelled, is generally as follows:
  - Overall cumulative mortality is higher in the reaches between Durham Ferry and Mossdale, which is common between the Old River route and the San Joaquin River route. The survival per kilometer is approximately 96% or higher but accounts for approximately 40-60% of overall mortality.
  - Cumulative mortality in the San Joaquin River route is inconsistent, with some years having high mortality in the reach between Mossdale and the Stockton Deepwater Ship Channel (Garwood Bridge/ Navy Bridge) and again in the lower reaches of the San Joaquin River route (MacDonald Island to Chipps Island).
  - Increased cumulative mortality in the Old River route occurs between the entrance to the Old River corridor (Old River south) and Chipps Island via the fish collection facilities.

Briefing on Six-year Study

June 26, 2018

Key Messages

Six-Year Study

- Four years of the total six years of studies have been written up as either final (2011-2013) or draft (2014) reports. Final reports just released in May/June 2018.
- Conditions during study years dominated by drought conditions.
- Survival results *(more details in Attachment 1, prepared by Jeff Stuart)*:
    - Through-Delta steelhead survival (for all routes combined) was highest in the Wet year (2011, and ranged from 15% (in 2013) to 54% (in 2011).
    - Absolute survival through the San Joaquin River route was better than the Old River route in three of the four analyzed study years (2011, 2012, and 2014) but not statistically significant (some power limitations?).
    - Reports do not provide analysis of survival as a function of the I:E ratio or OMR flow[1], though do evaluate total Delta survival as a function of Vernalis flow and some routing proportions as a function of local flows.
- Routing results:
    - Not surprisingly, the proportion of study fish in the San Joaquin River route was highest in the years when the HORB was installed.

SWFSC mini-project on Six-Year Study data

- Heads-up that SWFSC did a mini-analysis *(more details in Attachment 2, prepared by Caren Barceló)* to understand the relationship between detections at different receivers (detections being a surrogate for fish movement) and environmental variables (e.g. flow, turbidity, temperature, diel phase).
    - Preliminary results were that flow, conductivity and turbidity were the variables that most often had the strongest relationship (positive or negative) with the arrival rate of steelhead; associations differed for specific receivers.

Chinook releases in the San Joaquin River

- USFWS led studies of Chinook releases in the San Joaquin River, and measured through-Delta survival, in 2009-2015.
- For 2010-2013, through-Delta Chinook survival was <5% for all releases and survival was often higher in the Old River route (*see Attachment 3, prepared by Barb Byrne).*

[1] The 2013 report notes, for example, that "[The NMFS 2009 BiOp] identified flow at Vernalis, export volume, and the ratio of Vernalis flow-to-export as variables to test during this study as priority variables. Separating the effects of these covariates is difficult because the variables are likely to be correlated."

Overview of Six-year Study

- Studies released acoustically tagged **hatchery steelhead** into the San Joaquin River at Durham Ferry (most releases were from **late March to late May**) and tracked them through the Delta system using multiple releases and multiple acoustic receiver locations throughout the lower San Joaquin River and Delta (Figure 1).

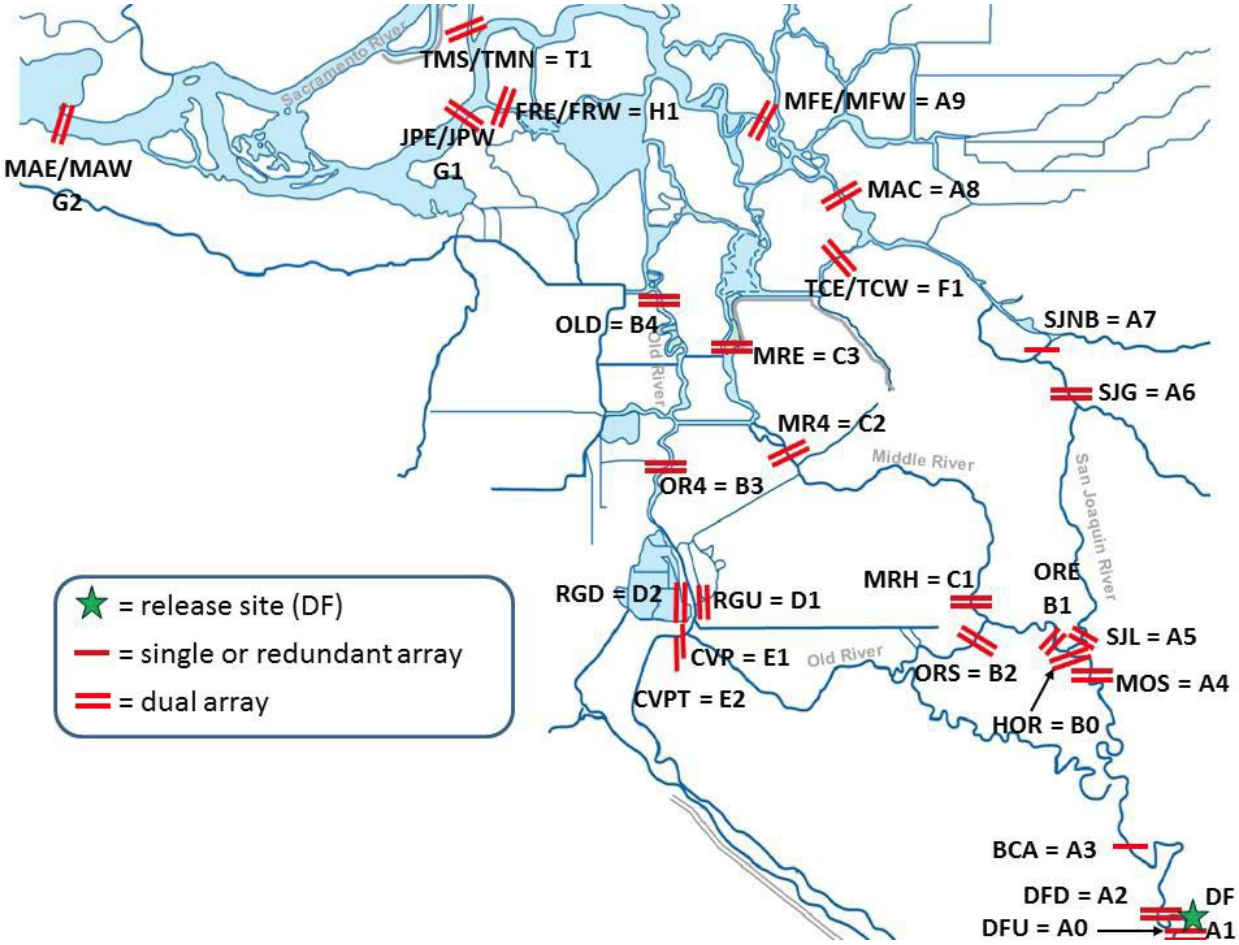


Figure 1. Locations of Acoustic Receivers for the 2012 study. Each year's study had a small number of additional/ removed or relocated acoustic receiver locations but the release location at Durham Ferry (DF) and westernmost receivers near Chipps Island (MAE & MAW) were consistent throughout.

- Studies occurred during a Wet year (2011) and five Dry or Critical years (2012-2016), as summarized in Table 1.

Table 1. Overview of hydrologic conditions and report status for the Six-year Study.

Water Year	HORB status	San Joaquin yeartype	I:E ratio in effect	14-day OMR range (in cfs, 4/1-5/31)	Vernalis flow range (in cfs, 4/1-5/31)	Status of report
2011	Out	Wet	Vernalis flow offramp 4/1-5/10; 4:1 from 5/11-5/31	2,391 to 9,520	9635 to 28,575	Final (May 2018)
2012	In	Dry	Joint Stipulation Study* in lieu of I:E ratio	-4,218 to -1,710	1,577 to 4,418	Final (May 2018)
2013	Out	Critical	1:1	-4,050 to -130	859 to 4,176	Final (June 2018)
2014	In	Critical	1:1	-4,750 to -1,650 *(based on Index)*	510 to 3,035	Draft (May 2018)
2015	In	Critical	1:1	-1,860 to -1,170 *(based on Index)*	254 to 1,433	*No report available*
2016	In	Dry	1:1	-3,720 to -1,860 *(based on Index)*	733 to 3,215	*No report available*

*OMR requirements in Joint Stipulation Study ranged from -1,250 cfs to -5,000 cfs.

- Survival and routing estimates (Table 2) show that:
  - Through-Delta steelhead survival (for all routes combined) was highest in the Wet year (2011, and ranged from 15% (in 2013) to 54% (in 2011). See Figure 2.
  - Absolute survival through the San Joaquin River route was better than the Old River route in three of the four study years (2011, 2012, and 2014) but not statistically significant[2].
  - Not surprisingly, the proportion of study fish in the San Joaquin River route was highest in the years when the HORB was installed.

[2] Power to detect survival differences between routes (excerpt from p.11 of the 2012 Report): "Buchanan (2010) recommended a sample size of 475 for estimating survival to Chipps down the Old River and San Joaquin routes if survival in the Old River route was low (0.05). Additionally, if survival between Durham Ferry and Chipps Island was higher (0.15) and survival between Durham Ferry and the Old River junction was high (0.9), a release of 475 at Durham Ferry would be able to detect a 50% difference between survival in the San Joaquin River and Old River routes. Thus, a release group of 475 at Durham Ferry was expected to provide accurate information about route entrainment and survival for examining biotic and abiotic factors influencing juvenile steelhead survival."

Table 2. Summary of hatchery steelhead survival estimates from Six-Year Study: 2011 - 2014

Study Year	Proportion using San Joaquin River route	Proportion using Old River route	Survival Probability Estimate: San Joaquin River Route	Survival Probability Estimate: Old River route	Survival Probability Estimate: Total Survival (any route)	HORB Status	Water Year Type
2011	0.51	0.49	0.55	0.52	0.54	Out	Wet
2012	0.94	0.06	0.33	0.07	0.32	In	Dry
2013	0.12	0.88	0.11	0.15	0.15	Out	Critical
2014	0.92	0.08	0.25	0.19	0.24	In	Critical

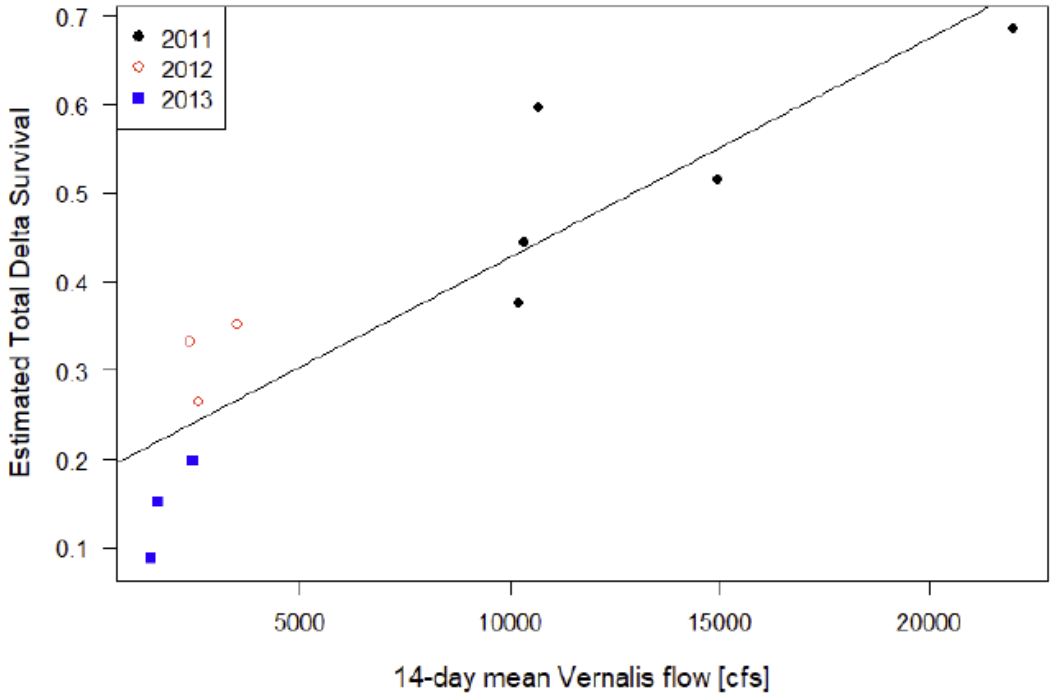


Figure 27. Estimated total delta survival (Mossdale to Chipps Island) for acoustic-tagged steelhead in the 2011, 2012, and 2013 Six-Year Study, versus 14-day mean San Joaquin River flow at Vernalis. Survival and flow data are from Tables 26 and 27. The line is the best fit linear predictor of survival as a function of 14-day Vernalis flow for these data ($r^2 = 0.8007$).

Figure 2. Estimated total Delta survival for hatchery steelhead from the 2011-2013 study years. (Figure 27 from the 2013 report)

- Other details available in Attachment 1:
  - Water temperatures were elevated (59 degrees F or higher) in three out of the four analyzed study years (2012-2014) during the fish releases.
  - Survival estimates by release group are provided in "heat-map" tables.
  - Releases are plotted along Vernalis flows and Mossdale water temperatures.

Highlights from 2011-2014 results from Six-Year Study

(summarizing 689 pages of draft and final reports)

- Four years of the total six years of studies have been written up as either final or draft reports
    - Final Reports available for 2011-2013
    - Draft report available for 2014
- Studies released acoustically tagged hatchery steelhead into the San Joaquin River at Durham Ferry and tracked them through the Delta system using multiple releases and multiple acoustic receiver locations throughout the lower San Joaquin River and Delta. (see Table 3 and Figure 3)
    - 2011 – Five releases, total of 2,196 fish tagged and released at Durham Ferry from late March through mid-June.
    - 2012 – Three release, total of 1,435 fish tagged and released at Durham Ferry from early April through mid-May.
    - 2013 – Three releases, total of 1,425 fish tagged and released at Durham Ferry from early March through early May.
    - 2014 – Three release, total of 1,432 fish tagged and released at Durham Ferry from late March through late May.
- Studies occurred during a wet year (2011) and three dry/critically dry years (2012-2014; the first three years of the 5-year drought) (see Figure 4).
    - Flows during the wet year (2011) were typically above 10,000 cfs at Vernalis, and peaked at approximately 29,000 cfs.
    - Flows during 2012 through 2014 were considerably less, never exceeding 5,000 cfs at at Vernalis, and typically less than 2,500 cfs for most of the period of interest.
    - The HOR barrier was installed during 2012 and 2014. In 2014 the HOR barrier went in after the first release of fish occurred. With the barrier in, few fish were entrained into the Old River route at the junction of Old River and the San Joaquin River (see Table 2 and Table 3a and 3b).
- During the wet year (2011) survival was better than the drought years (2012-2014) for both the San Joaquin River route (S_A) and the Old River route (S_B), as well as total survival (S_{total}) through the system. See Tables 2 and 3a and b.
    - Absolute survival through the San Joaquin River route was better than the Old River route in 3 of the 4 study years (2011, 2012, and 2014) but not statistically significant.
    - Survival through the sub-routes; south Delta and middle Delta (S_{SD} and S_{MD}), were variable and release group dependent. Clear distinctions between the Old river and San Joaquin River routes were not consistent.
- The presence of the HOR barrier was important in determining the proportion of fish entering Old River (see Table 4, Table 5, and Table 6) in relation to those remaining in the San Joaquin River route.
    - During low flow years, when the barrier was out, (2013, first release in 2014), and fish were released into the system at Durham Ferry, higher numbers of fish entered the Old River route at the HOR junction. This appears to be a function of river stage, tides, and shunting of flow into the Old River channel.

  - When flows were high (2011) the distribution of fish into Old River and the San Joaquin were nearly equal.
- Water temperatures were elevated in 3 out of the 4 study years (2012-2014) during the fish releases (see Figure 5, Figure 6, Figure 7, and Figure 8).
  - Waters temperatures (as measured at Mossdale) were consistently lower in 2011 compared to 2012-2014 during fish releases.
  - Water temperatures in 2012 were consistently above 18ºC for the second and third releases. Water temperatures following the first release were between 15 and 18ºC.
  - Water temperatures in 2013 were slightly below 15ºC during the first release, but were above 15ºC during the second and third releases.
  - Water temperatures in 2014 were between 15 and 18ºC during the three releases, with spikes following the first and third releases.
- Survival, as measured per kilometer travelled, is depicted in Tables 4 and 5, cumulative mortality /survival in Figure 9, Figure 10, Figure 11, Figure 12, Figure 13, and Figure 14.
  - Overall cumulative mortality is higher in the reaches between Durham Ferry and Mossdale (Figure 9, Figure 10, Figure 11, Figure 12, Figure 13, and Figure 14), which is common between the Old River route and the San Joaquin River route. The survival per kilometer is approximately 96% or higher (Table 7) but accounts for approximately 40-60% of overall mortality (Figure 9, Figure 10, Figure 11, Figure 12, Figure 13, and Figure 14).
  - Cumulative mortality in the San Joaquin River route is inconsistent, with some years having high mortality in the reach between Mossdale and the Stockton Deepwater Ship Channel (Garwood Bridge/ Navy Bridge) and again in the lower reaches of the San Joaquin River route (MacDonald Island to Chipps Island).
  - Increased cumulative mortality in the Old River route occurs between the entrance to the Old River corridor (Old River south) and Chipps Island via the fish collection facilities (Figure 10, Figure 12, and Figure 14).

Table 3. Number of steelhead with acoustic tags released for each study year. Note that because of differences in routing with HORB in vs. out, the sample size for the survival estimates in the San Joaquin River route vs. the Old River route is very different.

Study Year	Total # Tags Released	Release Groups	Date of Release	Number Tags Released	Number Assigned to Old River Route	Number Assigned to San Joaquin River route
2011	2,196	1	3/22 – 3/26	477		
HORB out		2	5/3 – 5/7	474		
		3	5/17 – 5/21	477		
		4	5/22 – 5/26	480		
		5	6/15 – 6/17	285		
2012	1,435	1	4/4 – 4/7	477	20	304
HORB in		2	5/1 – 5/6	478	11	297
		3	5/17 – 5/23	480	17	150
2013	1,425	1	3/6 – 3/9	476	278	16
HORB out		2	4/3 – 4/6	477	279	31
		3	5/8 – 5/11	472	265	40
2014	1,432	1	~3/26 – 3/29	474		
HORB in		2	~4/26 -4/29	480		
		3	~5/20 -5/23	478		

Table 4. Summary of 6-Year Steelhead Parameters: 2011 - 2014

Study Year	Proportion using SJR route (ψ_A)	Proportion using OR route (ψ_B)	Survival Probability Estimate: SJR Route (S_A)	Survival Probability Estimate: Old River Route (S_B)	Survival Probability Estimate: Total Survival (S_{Total})	HORB Status	Water Year Type
2011	0.51	0.49	0.55	0.52	0.54	Out	Wet
2012	0.94	0.06	0.33	0.07	0.32	In	Dry
2013	0.12	0.88	0.11	0.15	0.15	Out	Critical
2014	0.92	0.08	0.25	0.19	0.24	In	Critical

Model Parameters estimated:

$\boldsymbol{P_{hi}}$ = detection probability: probability of detection at telemetry station i within route h, conditional on surviving to station i, where i = ia, ib for the upstream, downstream receivers in a dual array, respectively.

$\boldsymbol{S_{hi}}$ = perceived survival probability: joint probability of migration and survival from telemetry station i to i+1 within route h, conditional on surviving to station i.

$\boldsymbol{\Psi_{hi}}$ = route selection probability: probability of a fish entering route h at junction l (l =1, 2, 3), conditional on fish surviving to junction l.

$\boldsymbol{\Phi_{kj,\ hi}}$ = transition probability: joint probability of migration, route selection, and survival; the probability of migrating, surviving, and moving from station j in route k to station i in route h, conditional on survival to station j in route k.

$\boldsymbol{\lambda}$ = joint transition and detection probability: joint probability of moving downstream from Chipps Island, surviving to Benicia Bridge, and detection at Benicia Bridge, conditional on survival to Chipps Island.

Table 5. Performance metric estimates for tagged juvenile steelhead for study years 2011 -2012, excluding predator – type detections. Standard errors in parentheses.

Parameter	2011 Release Group 1	2011 Release Group 2	2011 Release Group 3	2011 Release Group 4	2011 Release Group 5	Pop Est.		2012 Release Group 1	2012 Release Group 2	2012 Release Group 3	Pop Est
Ψ_{AA}	0.47 (0.03)	0.35 90.03)	0.37 (0.03)	0.36 (003)		0.39 (0.02)		0.72 (0.04)	0.75 (0.03)	0.58 (0.04)	0.68 (0.02)
Ψ_{AF}	0.05 (0.01)	0.16 (0.02)	0.12 (0.02)	0.17 (0.02)		0.12 (0.01)		0.21 (0.04)	0.23 (0.03)	0.26 (0.02)	0.26 (0.02)
Ψ_{BB}	0.44 (0.0)	0.46 (0.03)	0.49 (0.03)	0.45 (0.03)		0.46 (0.02)		0.06 (0.01)[a]	0.03 (0.01)[a]	0.06 (0.01)[a]	0.06 (0.01)[a]
Ψ_{BC}	0.04 (0.01)	0.03 (0.01)	0.01 (0.01)	0.03 (0.02)		0.03 (0.01)		0.00[a]	0.00[a]	0.00 [a]	0.00 [a]
S_{AA}	0.72 (0.04)	0.68 (0.05)	0.51 (0.05)	0.69 (0.05)		0.65 (0.02)		0.33 (0.03)	0.43 (0.03)	0.45 (0.05)	0.40 (0.02)
S_{AF}	0.33 (0.12)	0.27 (0.07)	0.26 (0.07)	0.59 (0.07)		0.36 (0.04)		0.10 (0.04)	0.14 (0.04)	0.21 (0.05)	0.15 (0.03)
S_{BB}	0.68 (0.04)	0.50 (0.05)	0.44 (0.04)	0.55 (0.05)		0.54 (0.02)		0.07 (0.04)	0.10 (0.07)	0.05 (0.03)	0.07 (0.03)
S_{BC}	0.67 (0.08)	0.30 (0.13)	0.48 (0.06)	0.22 (0.17)		0.42 (0.06)		NA	NA	NA	NA
Ψ_{A}	0.52 (0.03)	0.51 (0.03)	0.49 (0.03)	0.53 (0.03)	0.52 (0.05)	0.51 (0.02)		0.94 (0.01)*	0.97 (0.01)*	0.92 (0.02)*	0.94 (0.01)*
Ψ_{B}	0.48 (0.03)	0.49 (003)	0.51 (0.03)	0.47 (0.03)	0.48 (0.05)	0.49 (0.02)		0.06 (0.01)*	0.03 (0.01)*	0.08 (0.02)*	0.06 (0.01)*
S_{A}	0.69 (0.04)	0.55 (0.04)	0.45 (0.04)	0.66 (0.04)*	0.32 (0.06)	0.55 (0.02)		0.28 (0.03)	0.33 (0.03)	0.36 (0.04)	0.33 (0.02)
S_{B}	0.68 (0.04)	0.48 (0.04)	0.44 (0.04)	0.53 (0.05)*	0.44 (0.07)	0.52 (0.02)		0.07 (0.04)	0.10 (0.07)	0.05 (0.03)	0.07 (0.03)
S_{Total}	0.69 (0.03)	0.52 (0.03)	0.44 (0.03)	0.60 (0.03)	0.38 (0.05)	0.54 (0.01)		0.26 (0.02)	0.35 (0.03)	0.33 (0.04)	0.32 (0.02)
$S_{A(MD)}$	0.82 (0.03)*	0.50 (0.04)*	0.39 (0.04)*	0.52 (0.04)*		0.56 (0.02)		0.32 (0.03)	0.46 (0.03)	0.45 (0.04)	0.41 (0.02)
$S_{B(MD)}$	0.53 (0.04)*	0.05 (0.02)*	0.09 (0.03)*	0.06 (0.02)*		0.18 (0.01)		0.00[a]	0.00	0.00	0.00
$S_{Total(MD)}$	0.68 (0.03)	0.28 (0.03)	0.24 (0.03)	0.30 (0.03)		0.37 (0.01)		0.30 (0.03)	0.45 (0.03)	0.41 (0.04)	0.39 (0.02)
$S_{A(SD)}$	0.89 (0.03)	0.83 (0.03)	0.74 (0.04)	0.85 (0.03)		0.83 (0.02)		0.78 (0.04)	0.82 (0.02)	0.89 (0.03)	0.83 (0.02)
$S_{B(SD)}$	0.91 (0.03)	0.75 (0.04)	0.71 (0.04)	0.77 (0.04)		0.78 (0.02)		0.80 (0.08)	0.62 (0.17)	0.23 (0.11)	0.55 (0.07)
$S_{Total(SD)}$	0.90 (0.02)	0.79 (0.03)	0.72 (0.03)	0.81 (0.03)		0.81 (0.01)		0.78 (0.04)	0.81 (0.02)	0.84 (0.03)	0.81 (0.02)

* Significantly different at $\alpha = 0.05$

[a] No tags were detected in subroute "C" or insufficient tags were detected to subroute "C" for use in analysis. No estimate for survival in subroute C was available.

Table 6. Performance metric estimates for tagged juvenile steelhead for study years 2013 -2014, excluding predator – type detections. Standard errors in parentheses.

Parameter	2013 Release Group 1	2013 Release Group 2	2013 Release Group 3	Pop Est.		2014 Release Group 1	2014 Release Group 2	2014 Release Group 3	Pop Est
Ψ_{AA}	NA[a]	0.07(0.02)	0.11 (0.02)	NA[a]		NA[a]	0.66 (0.03)	0.77 (0.08)	0.71 (0.04)
Ψ_{AF}	NA[a]	0.06 (0.02)	0.05 (0.02)	NA[a]		NA[a]	0.30 (0.03)	0.11 (0.07)	0.21 (0.04)
Ψ_{BB}	0.89 (0.02)	0.85 (0.02)	0.83 (0.02)	0.86 (0.01)		0.87 (0.03)	0.04 (0.01)	NA[a]	NA[a]
Ψ_{BC}	0.03 (0.01)	0.02 (0.01)	0.01 (0.01)	0.02 (<0.01)		0.04 (0.02)	0.00 (<0.01)	NA[a]	NA[a]
S_{AA}	NA[a]	0.19 (0.07)	0.31 (0.07)	NA[a]		NA[a]	0.57 (0.03)	0.07)0.03)	0.32 (0.02)
S_{AF}	NA[a]	0.06 (0.05)	0.00	NA[a]		NA[a]	0.13 (0.03)	NA[a]	NA[a]
S_{BB}	0.17 (0.02)	0.08 (0.02)	0.20 (0.03)	0.15 (0.01)		0.20 (0.04)	0.33 (0.09)	NA[a]	NA[a]
S_{BC}	0.07 (0.05)	0.06 (0.04)	0.06 (0.06)	0.06 (0.03)		0	NA[a]	NA[a]	NA[a]
Ψ_{A}	0.08 (0.02)	0.12 (0.02)	0.16 (0.02)	0.12 (0.01)		0.09 (0.02)	0.96 (0.01)	0.88 (0.03)	0.92 (0.02)
Ψ_{B}	0.92 (0.02)	0.88 (0.02)	0.84 (0.02)	0.88 (0.01)		0.91 (0.02)	0.04 (0.01)	0.12 (0.03)	0.08 (0.02)
S_{A}	0.00	0.13 (0.05)	0.20 (0.06)	0.11 (0.03)		0	0.43 (0.03)	0.06 (0.02)	0.25 (0.02)
S_{B}	0.16 (0.02)	0.08 (0.02)	0.20 (0.02)	0.15 (0.01)		0.19 (0.03)	0.31 (0.09)	0.07 (0.07)	0.19 (0.06)
S_{Total}	0.15 (0.02)	0.09 (0.02)	0.20 (0.02)	0.15 (0.01)		0.18 (0.03)	0.43 (0.03)	0.06 (0.02)	0.24 (0.02)
$S_{A(MD)}$	0.00	0.13 (0.05)	0.24 (0.06)	0.12 (0.03)		NA[a]	0.44 (0.03)	0.07 (0.03)	0.26 (0.02)
$S_{B(MD)}$	0.01 (0.01)	0.01 (0.1)	0.06 (0.02)	0.03 (0.01)		NA[a]	0	NA[a]	NA[a]
$S_{Total(MD)}$	0.01 (0.01)	0.03 (0.01)	0.09 (0.02)	0.04 (0.01)		NA[a]	0.43 (0.03)	NA[a]	NA[a]
$S_{A(SD)}$	NA[a]	0.23 (0.07)	0.37 (0.07)	NA[a]		NA[a]	0.77 (0.02)	0.16 (0.04)	0.46 (0.02)
$S_{B(SD)}$	0.53 (0.03)	0.56 (0.03)	0.75 (0.03)	0.61 (0.02)		0.56 (0.04)	0.83 (0.09)	NA[a]	NA[a]
$S_{Total(SD)}$	NA[a]	0.52 (0.03)	0.69 (0.03)	NA[a]		NA[a]	0.77 (0.02)	NA[a]	NA[a]

[a] NA estimates resulted when there were too few tags detected in the route to estimate route selection and/or survival.

Table 7. Heat Map Depicting Steelhead Survival Rates (S(1/km)) Through San Joaquin River Reaches to Chipps Island.

Reach Name	km	2011 CAMT SST	2011 6-year Rpt	2012 CAMP SST	2012 6-year Rpt	2013 6-year Rpt	2014 6-year Rpt
Durham Ferry to Banta Carbona	11	0.962	0.9765	0.967	0.986	0.988	0.973
Banta Carbona to Mossdale	10	0.982	0.985	0.978	0.980	0.985	0.980
Mossdale to Lathrop/Old River	4	0.985	0.985	0.995	0.995	0.995	0.966
Lathrop to Garwood Bridge (SJR)	18	0.995	0.995	0.997	0.997	0.948	0.974
Garwood Bridge to Navy Bridge	3	0.993	0.993	0.990	0.990	0.958	0.976
Navy Bridge to Turner Cut/MacDonald Island	15	0.997	0.997	0.994	0.994	0.984	0.984
MacDonald Island to Medford Island	5	0.942	0.949	0.923	0.941		
Turner Cut to Jersey Point (includes interior Delta route but not SJR route)	28	0.958	0.957	0.934	0.933		
Medford to Jersey Point	21	0.992		0.987			
Jersey Point to Chipps Island	22	0.997		0.989			

Note: Darker red boxes have lower survival values and lighter boxes indicate higher survival rates (white ≥ 99% survival/km). Missing values reflect sparse data in the reach in question or the study had deficiencies that prevented estimates to be made.

Table 8. Heat Map depicting Survival Rates (S(1/km)) through Old River Reaches to Chipps Island.

Reach Name	km	2011 CAMT SST	2011 6-year Rpt	2012 CAMP SST	2012 6-year Rpt	2013 6-year Rpt	2014 6-year Rpt
Old River (Head) to Middle River Head/ Old River (south)	6	0.990	0.9897	0.977	0.977	0.990	0.948
Old River (South) to CVP/CCF/HWY4	20	0.994	0.988	0.977	0.977	0.981	0.983
Old River (HWY4) to Jersey Point	60	0.992	0.992	0.958		0.972	0.978
CVP Holding Tank to Chipps Island	15	0.988	0.992	0.973	0.965	0.987	1.0/0.98
CCF Radial Gate (interior) to Chipps Island	24	0.979	0.983	0.924	0.914	0.957	0/ 0.95

Note: Darker red boxes have lower survival values and lighter boxes indicate higher survival rates (white ≥ 99% survival/km). Missing values reflect sparse data in the reach in question or the study had deficiencies that prevented estimates to be made.

Yellow highlighted cells have two survival estimates. Estimate from the first release in 2014 have a survival rate of 98% from the CVP holding tank to Chipps Island, and a survival rate of 95% from the CCFB interior radial gates to Chipps Island based on a joint tag survival and fish survival estimates due to premature tag failures occurring in the first release group. The 100 % survival for the CVP estimate is based on the second and third releases with a total of 12 fish detected in the holding tank and 12 fish detected at Chipps Island. The zero survival for the CCFB radial gate to Chipps Island is based on 3 fish detected at the interior radial gate with none subsequently detected at Chipps Island.

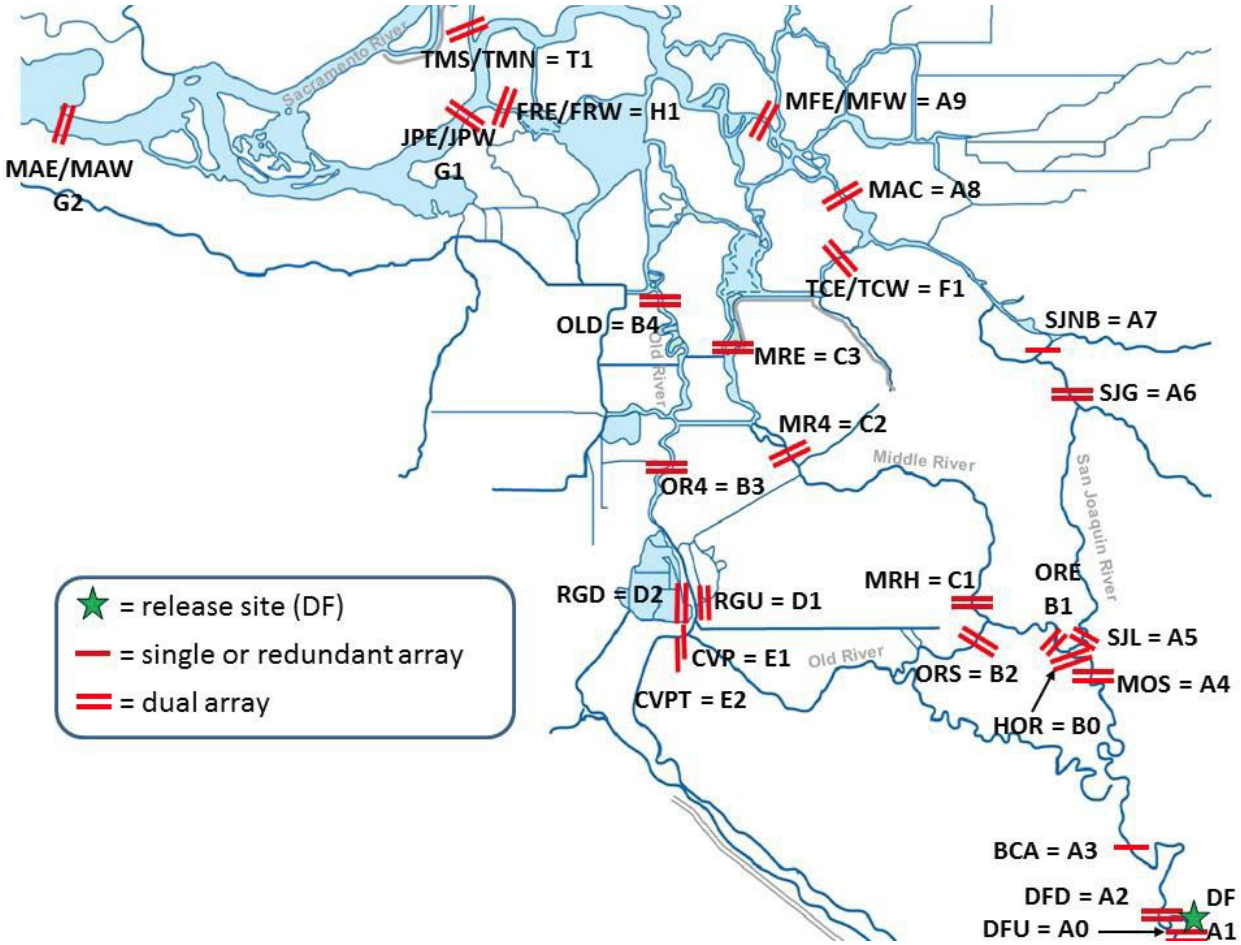


Figure 3. Locations of Acoustic Receivers (general locations) as each study had a small number of additional/ removed or relocated acoustic receiver locations. (2012 study locations used as an example).

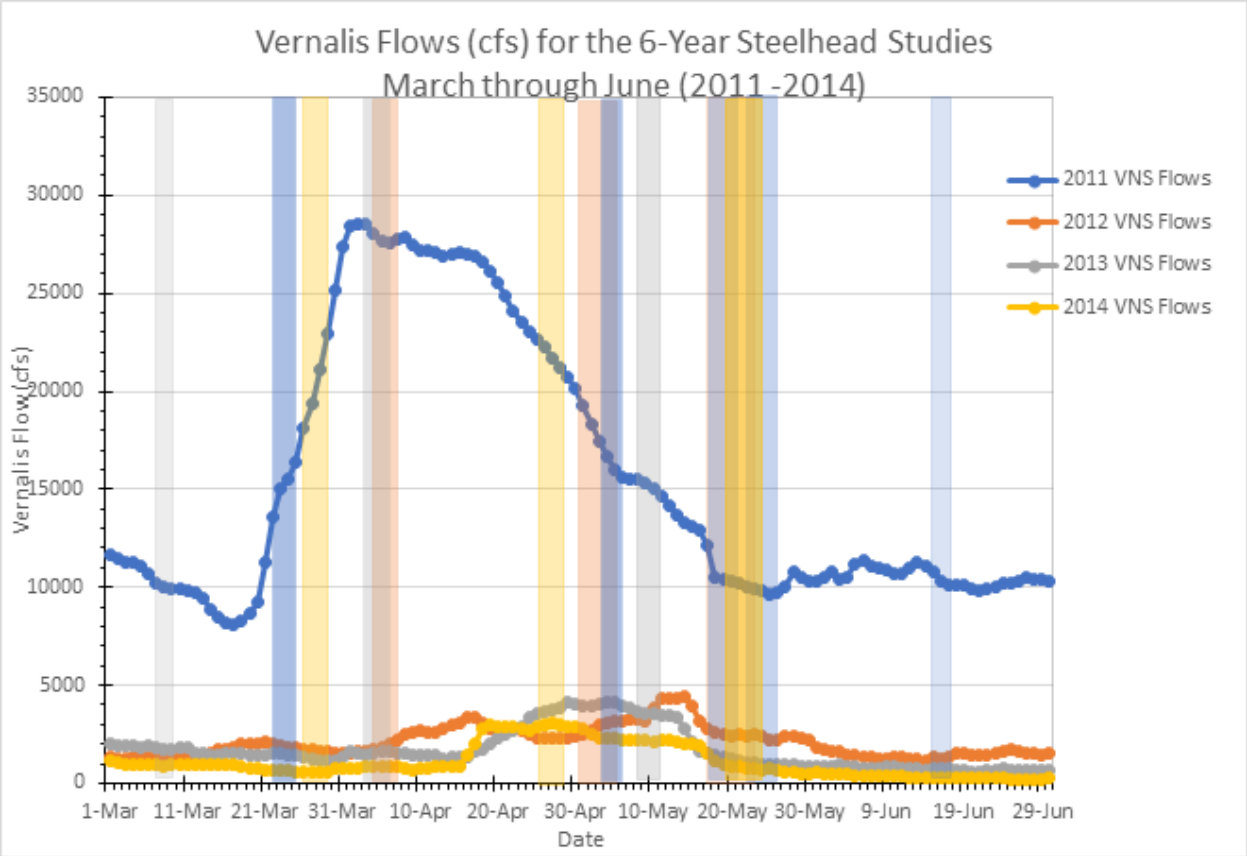


Figure 4. March through June Vernalis Flows for Study Years 2011 – 2014 with release groups.

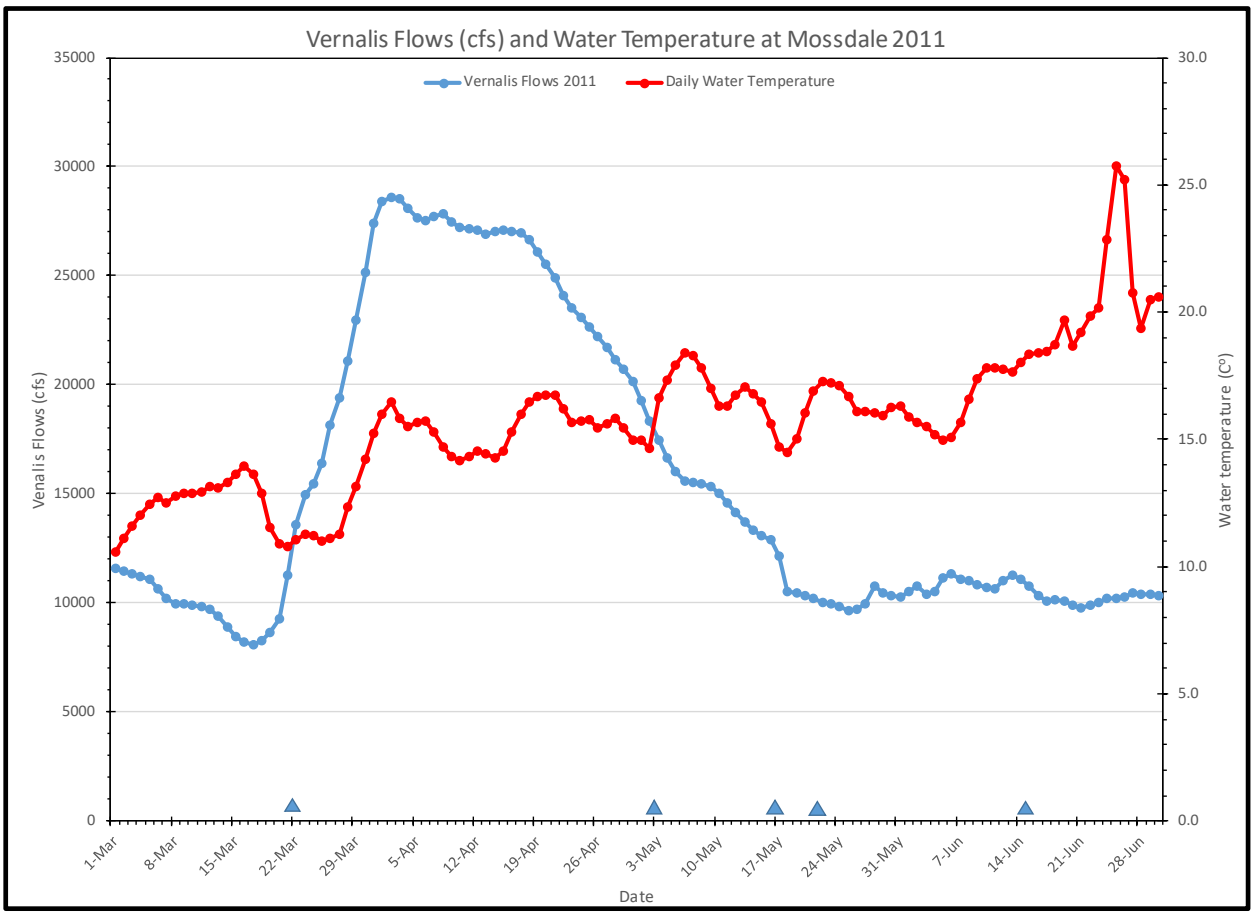


Figure 5. Vernalis Flows and Mossdale Water Temperatures March through June 2011

Triangles depict the initial date of releases for each release groups

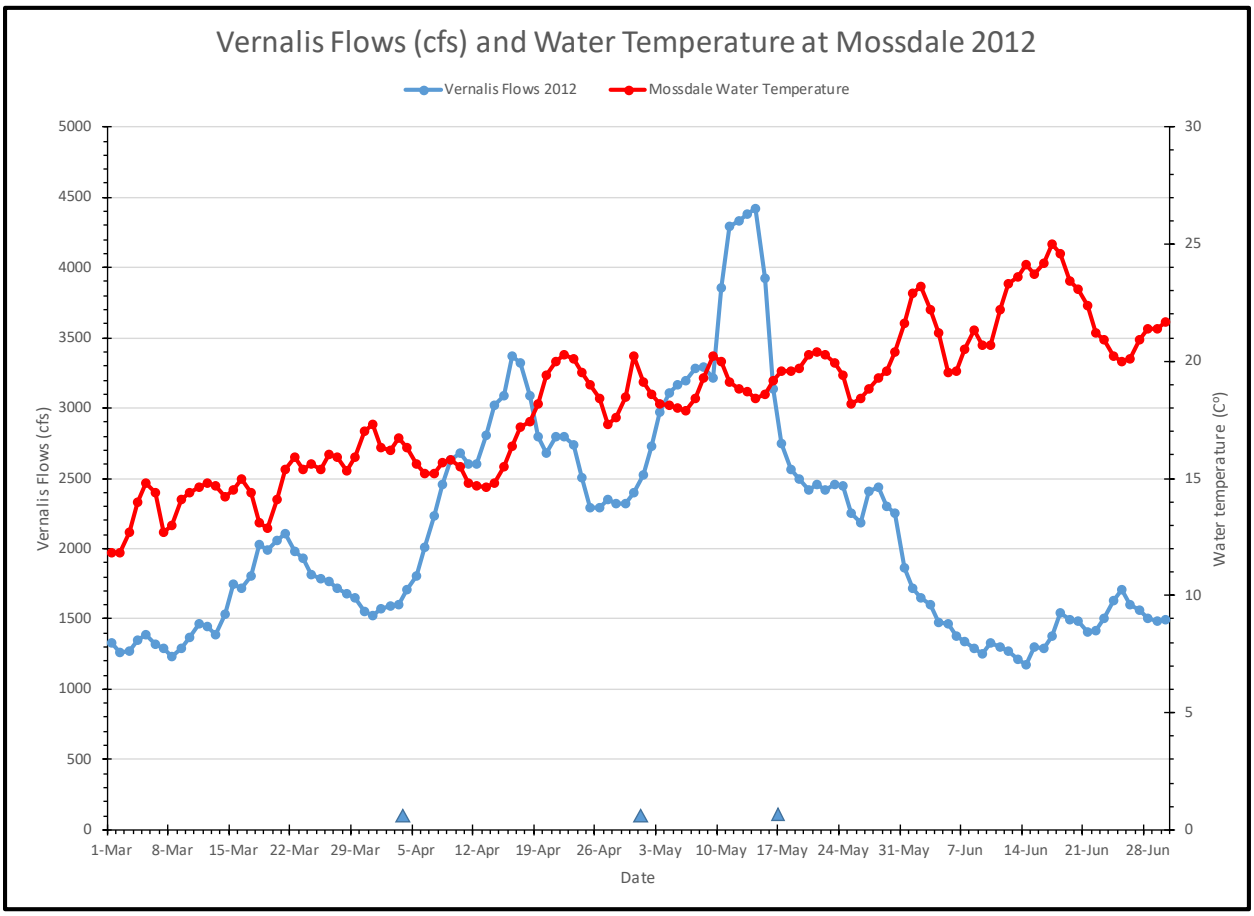


Figure 6. Vernalis Flows and Mossdale Water Temperatures March through June 2012

Triangles depict the initial date of releases for each release groups

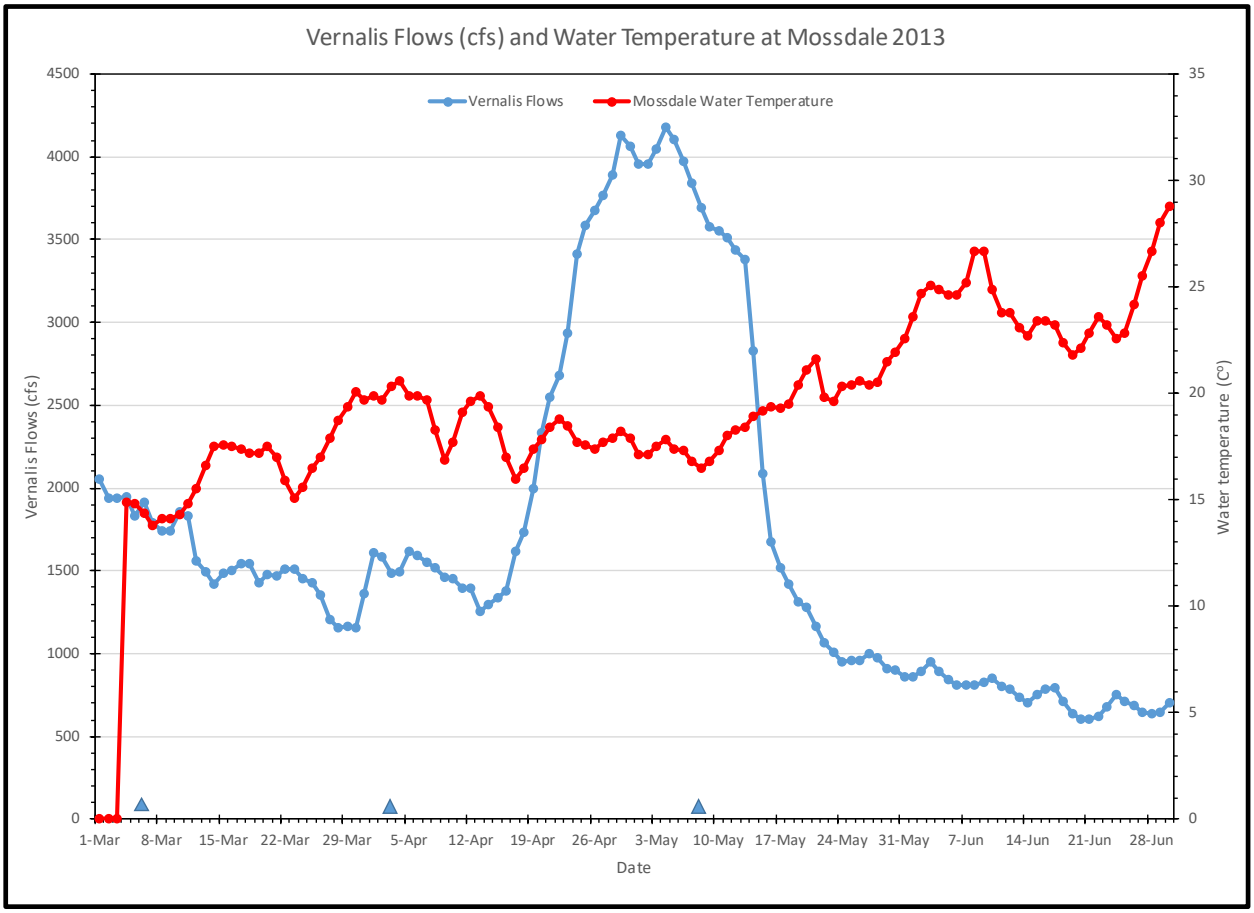


Figure 7. Vernalis Flows and Mossdale Water Temperatures March through June 2013

Triangles depict the initial date of releases for each release groups

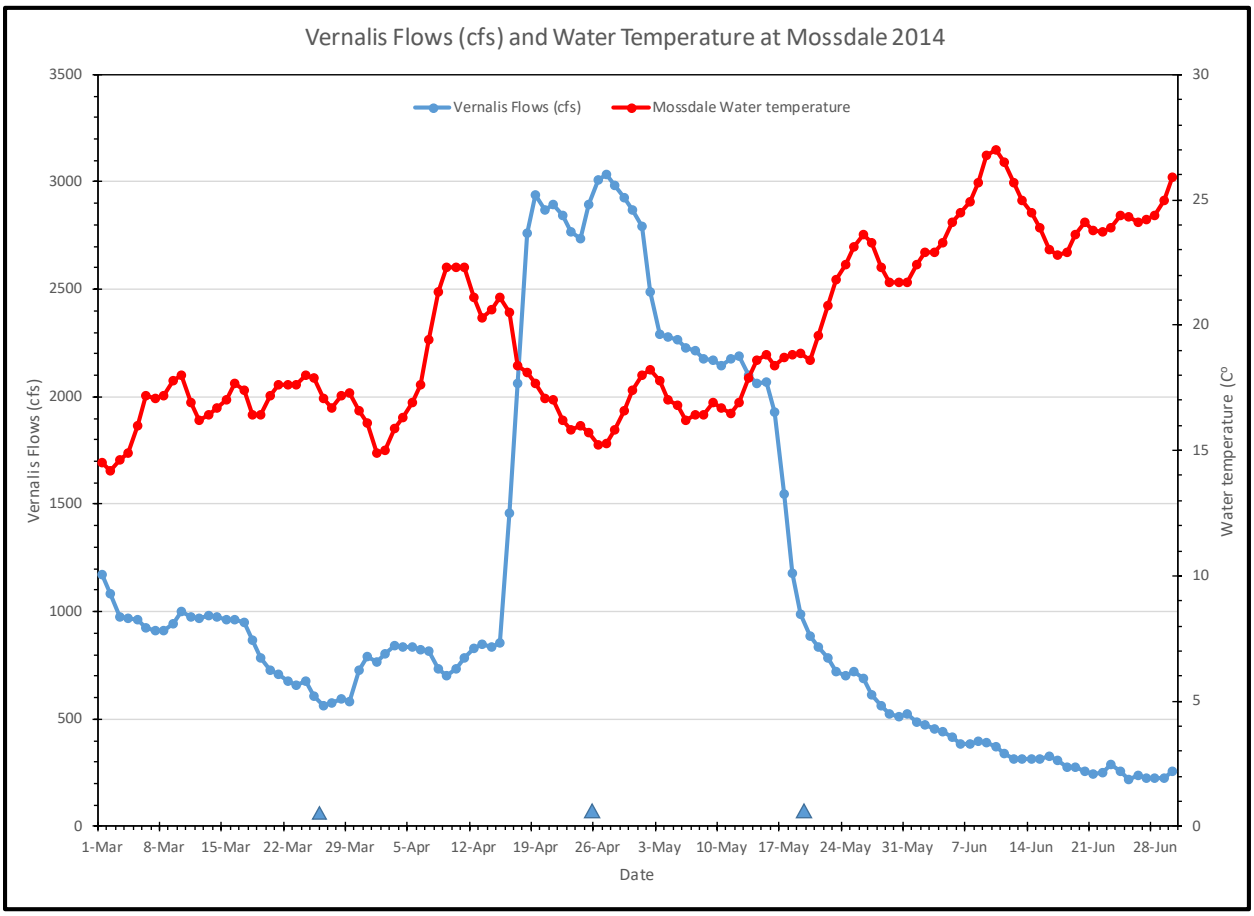


Figure 8. Vernalis Flows and Mossdale Water Temperatures March through June 2014

Triangles depict the initial date of releases for each release groups

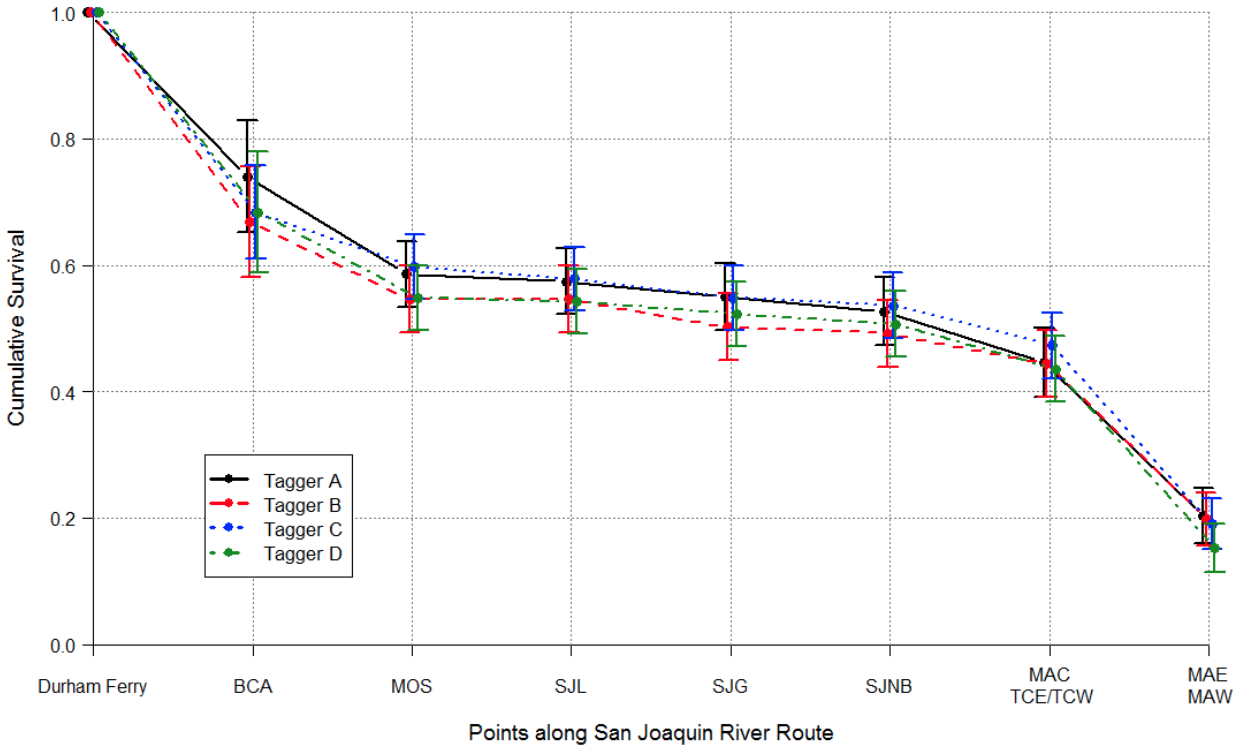


Figure 9. Cumulative survival from releases at Durham Ferry to various points along the San Joaquin River route to Chipps Island by surgeon (2012 study). Error bars are 95% confidence intervals.

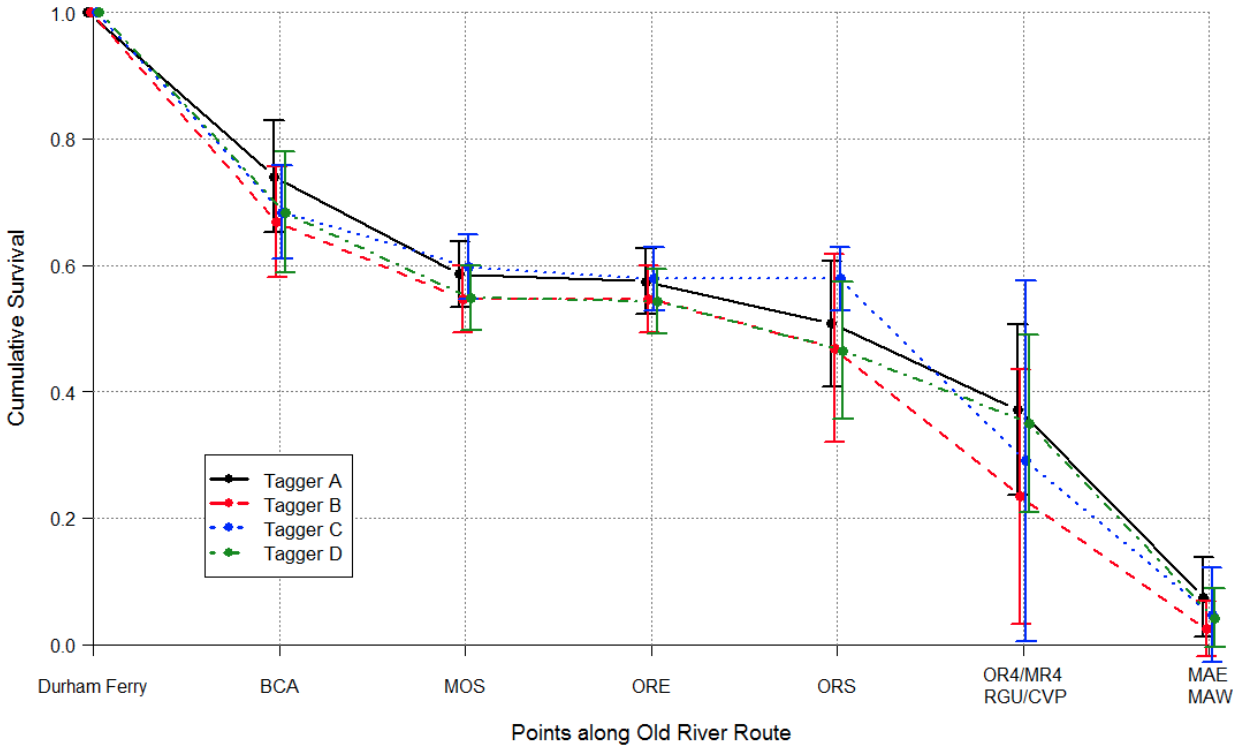


Figure 10. Cumulative survival from releases at Durham Ferry to various points along the Old River route to Chipps Island by surgeon (2012 study). Error bars are 95% confidence intervals.

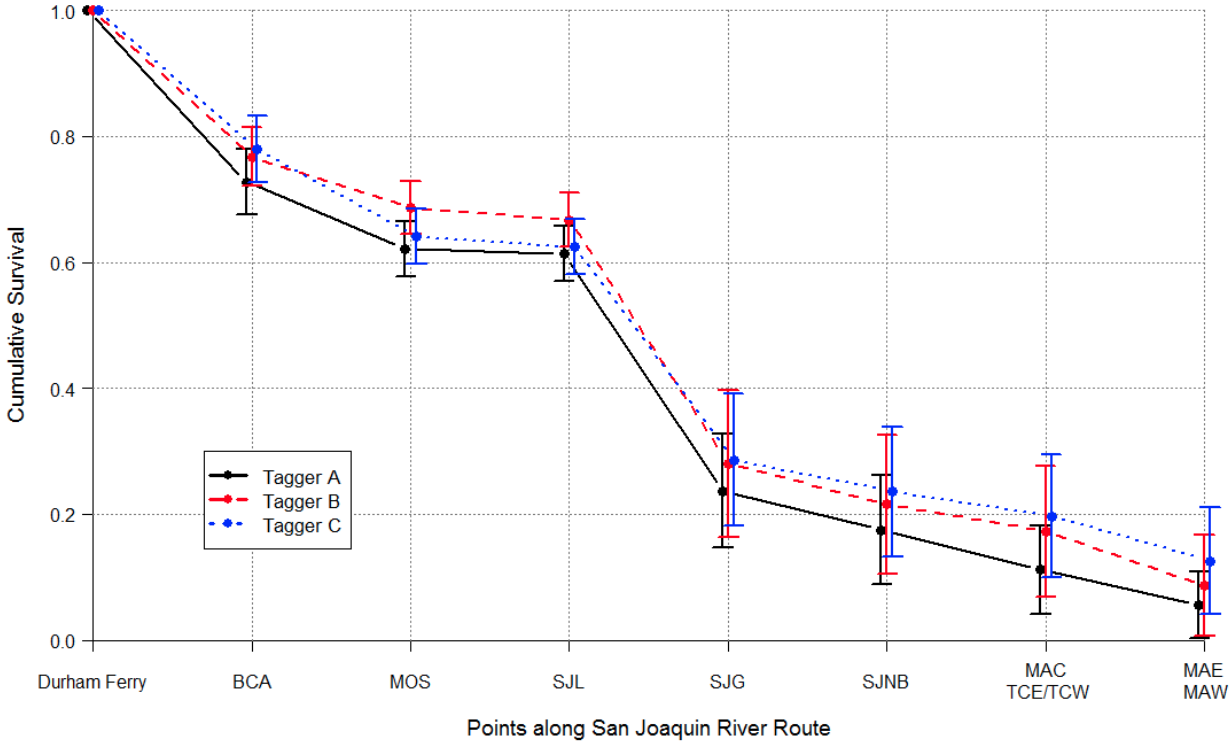


Figure 11. Cumulative survival from releases at Durham Ferry to various points along the San Joaquin River route to Chipps Island by surgeon (2013 study). Error bars are 95% confidence intervals.

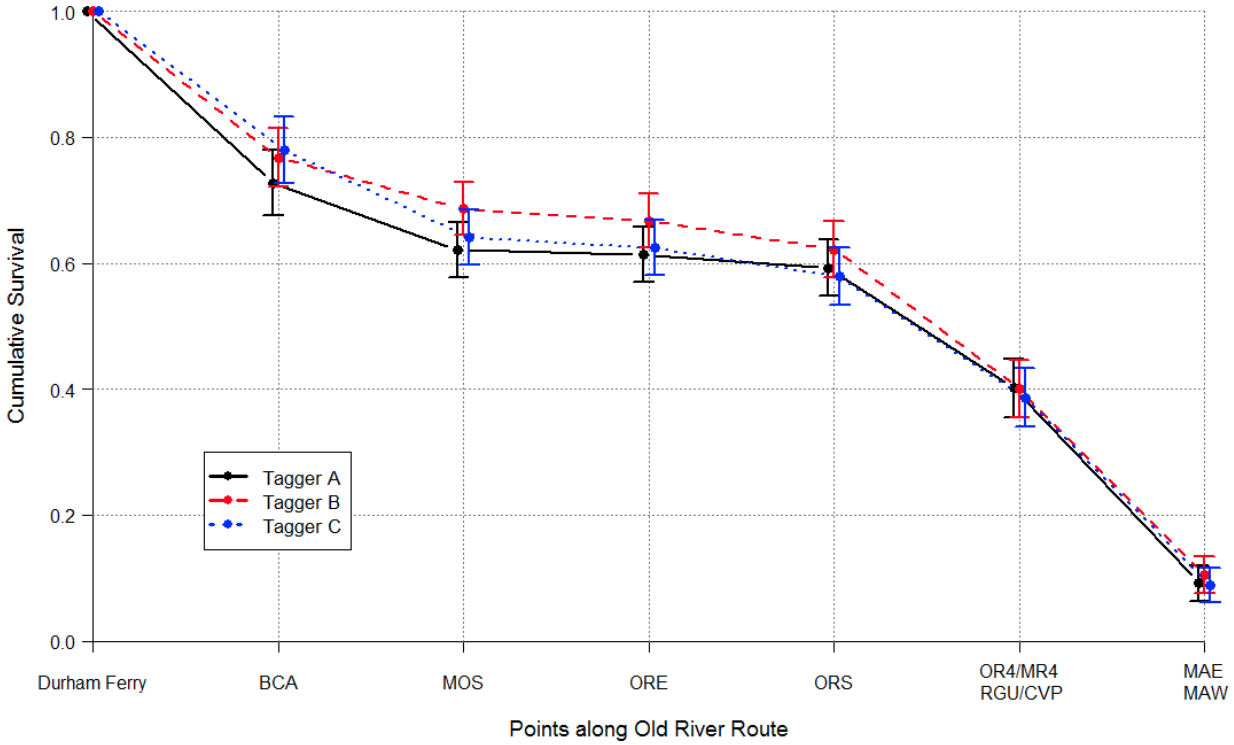


Figure 12. Cumulative survival from releases at Durham Ferry to various points along the Old River route to Chipps Island by surgeon (2013 study). Error bars are 95% confidence intervals.

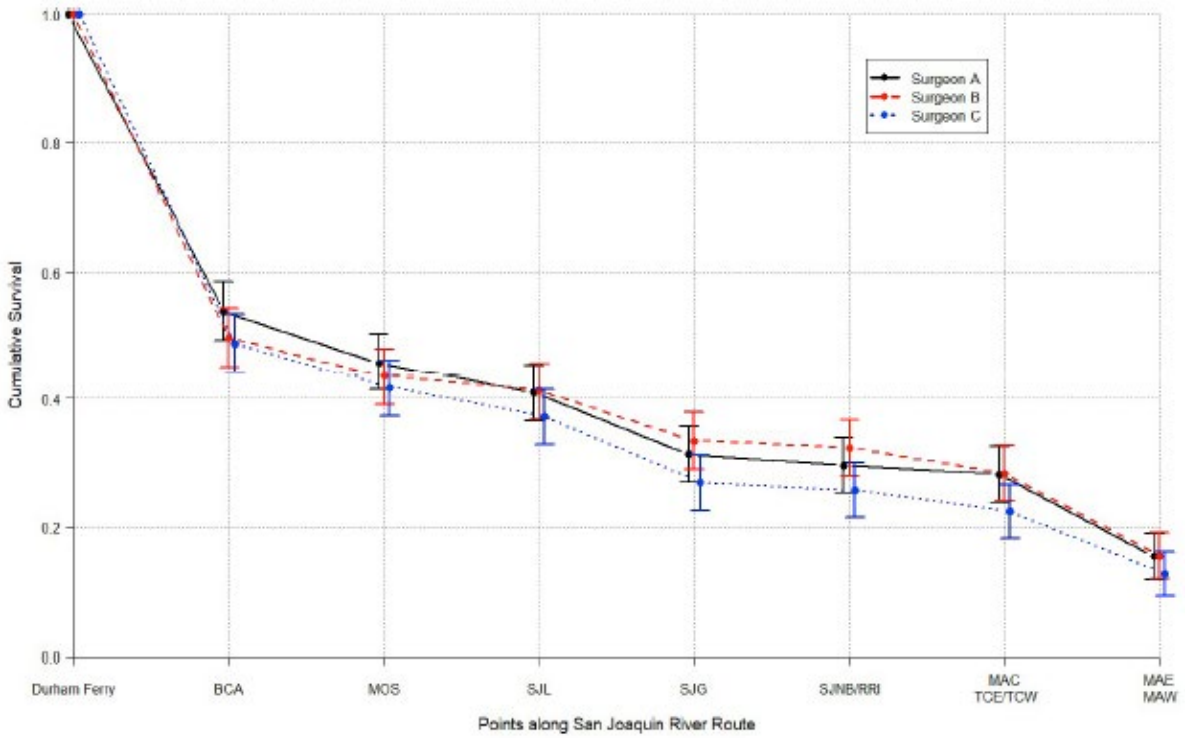


Figure 13. Cumulative survival from releases at Durham Ferry to various points along the San Joaquin River route to Chipps Island by surgeon (2014 study). Error bars are 95% confidence intervals. Estimates are of joint fish-tag survival.

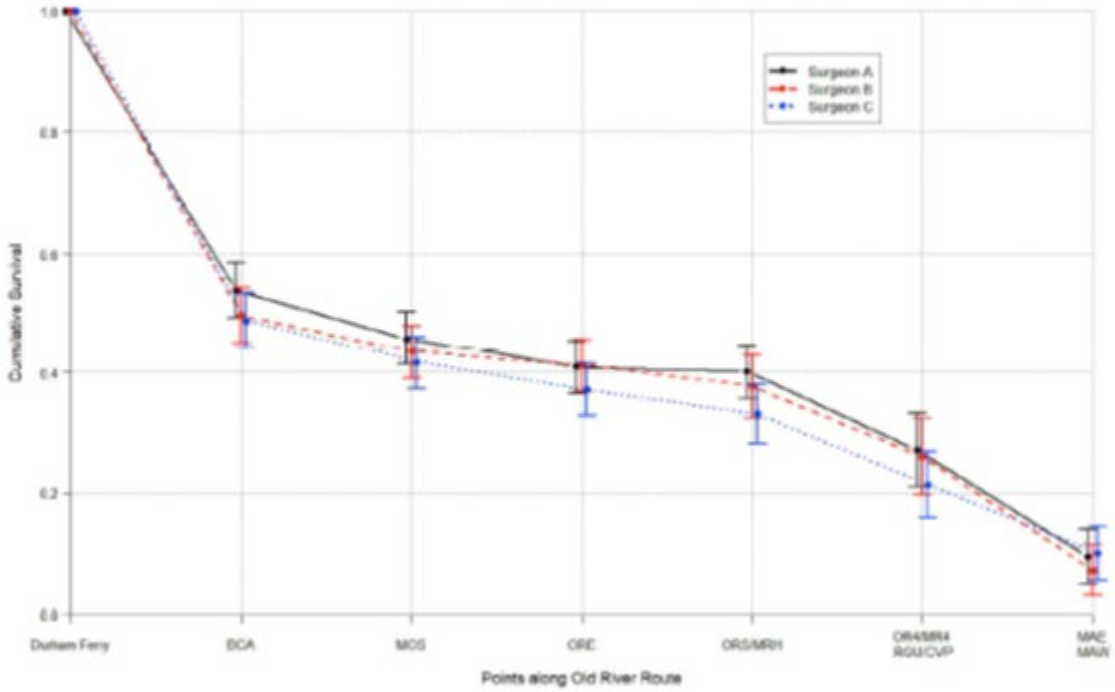


Figure 14. Cumulative survival from releases at Durham Ferry to various points along the Old River route to Chipps Island by surgeon (2014 study). Error bars are 95% confidence intervals. Estimates are of joint fish-tag survival.

Summary of SWFSC report to USBR on analysis on subset of Steelhead "6-year Study" acoustic telemetry data

Background: The SWFSC (Dr. Andrew Hein) used a subset of six-year study steelhead acoustic telemetry data at five hydrophone arrays in the Delta to understand the relationship between the instantaneous migration rate and environmental variables using a novel point process statistical model framework. The instantaneous migration rate refers to the minute-by-minute fish movements into the zone within range of detection by a hydrophone array, rather than the long-term movements of fish throughout the system.

Methods (refer to Figure 15**):** Acoustically tagged fish were released at Durham Ferry (release location) and subset for analysis purposes to include mostly 2011 data. The environmental variables of interest were turbidity, conductivity, temperature, diel phase, discharge, and the rate of discharge over time. These data were subjected to a symbolic regression (point process model) aimed at generating a variety of models to predict the instantaneous movement behavior in response to different environmental variables, specifically the expected arrival of fish at location x and time t.

Results (refer to Figure 16**):** Discharge, conductivity and turbidity were the variables that most often had the strongest relationship with the arrival rate of steelhead at the subset of hydrophone arrays investigated. The conditional effects of each environmental variable (varying one variable at a time while holding all others at their mean value) for each hydrophone array location are described below:

- At **BCA** (near release site), arrivals of fish were negatively related to discharge, and positively related with warmer and more turbid water conditions.
- At **SJL,** turbidity and temperature exerted dominant effects on arrival rates with a slightly less pronounced effect of water conductivity, however discharge did not have a strong influence. The conductivity effect was stronger than at other arrays higher in the river.
- At **Turner Cut (C18/16),** a more tidally influenced region, the fish moved most with high conductivity, discharge, temperature and turbidity – with discharge and conductivity having the strongest positive relationship with arrivals. (More tidal region)
- At **Jersey Point (JPT)** arrival rates were positively correlated with conductivity with less influence to no relationship with other variables. (More tidal region)
- At the **Old River (ORN)** hydrophone array, there was a different pattern in arrivals in relation to environmental variables than at other arrays investigated here. Specifically, predicted fish arrival rates increased with strong negative flows and with positive flows (a non-linear relationship) with also a small net positive effect of turbidity.

Caveats: The analysis in this report was done as a proof of concept for the modelling framework, not to answer specific management related questions. Only one full year of data was used (2011) and as such results only provide a partial understanding of conditions that might affect steelhead movement during dry years. Further, models assume that detection probability for a given hydrophone array are constant but there is likely different detection probabilities through time for each array. The models also do not necessarily use the most representative

(closest) gauge data for environmental data to model with arrival detections. Other gauges or hydrological models might be appropriate to use here to couple environmental conditions with arrival detections at hydrophone locations.

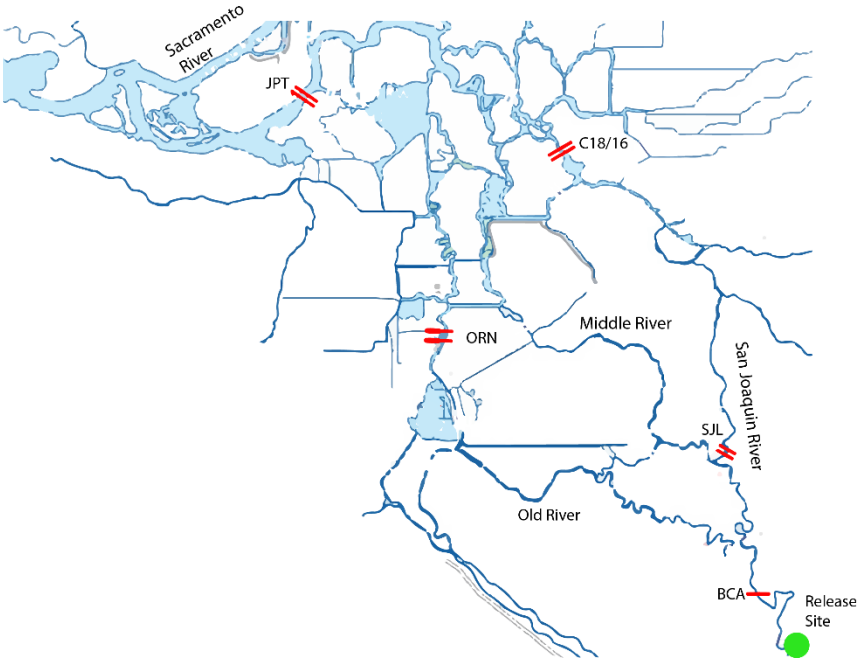


Figure 15. Map of the Sacramento/San-Joaquin Delta with locations of single or dual hydrophone arrays (represented by one and two red bars, respectively) used in the analysis.

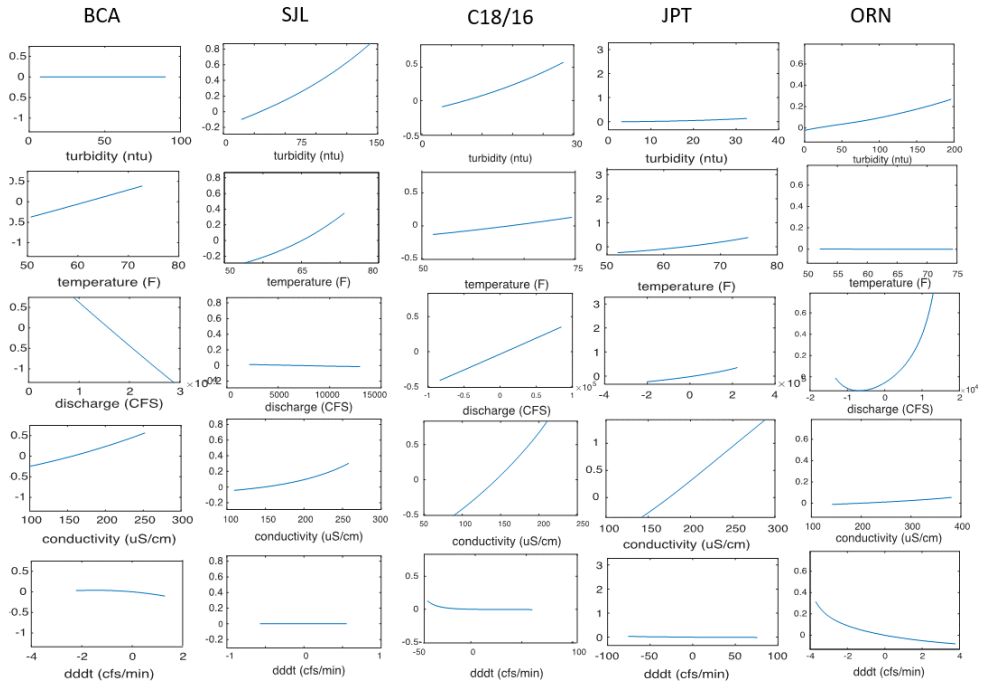


Figure 16. Model averaged conditional effect of each environmental variable (holding others constant at mean values) on arrival rates for each hydrophone array within the Delta. Column names (BCA, SJL, C18/16, JPT, ORN) refer to individual hydrophone arrays within the Delta identified in Fig 1.

Chinook survival results

Results from:

Brandes et al. 2017, Multivariate San Joaquin River Chinook Salmon Survival Investigation, 2012-2013. USFWS report. 6 October 2017.

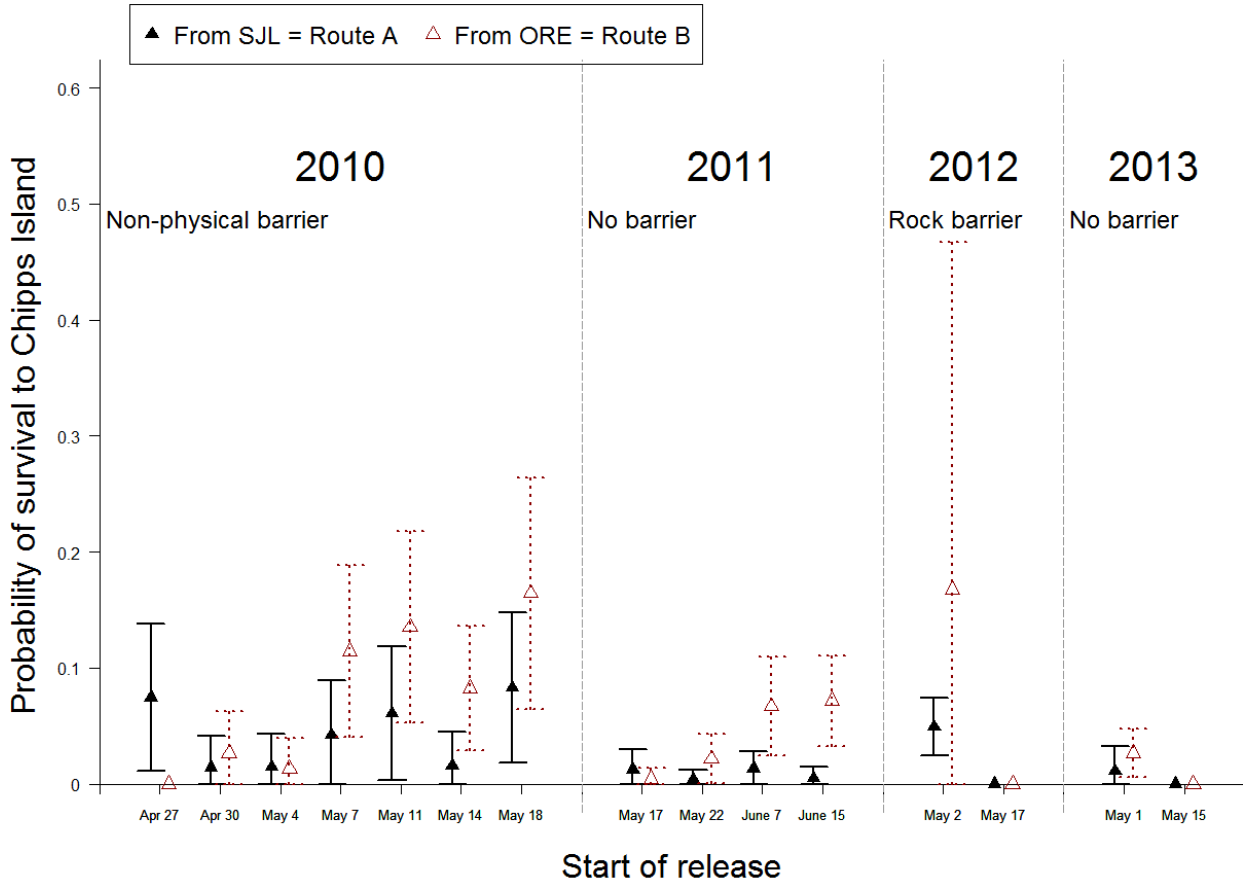


Figure 17. Estimated probabilities of surviving from the head of Old River (SJL or ORE receivers) to Chipps Island for the San Joaquin River route (Route A) and the Old River route (Route B), for each study year and release group; bars indicate asymptotic 95% confidence intervals. Route is determined at the head of Old River; salmon in the San Joaquin River route may enter the interior Delta further downstream.

- **Outmigration survival of salmonid smolts in riverine waterways increases with increasing flow** – this result is consistent for Chinook and steelhead from both the Sacramento (Henderson et al. 2019, Michel et al. 2021, and Notch et al. 2020) and San Joaquin (Buchanan et al. 2021, Buchanan et al. 2018) basins.
- Riverine conditions (i.e. with unidirectional downstream flow, rather than tidally reversing flow) are present in the mainstem Sacramento River and San Joaquin River upstream of the Delta, and **the extent to which those riverine conditions extend into the Delta increases with inflow from each basin** (Cavallo et al. 2013)**.**
- **In tidally-reversing channels of the interior Delta, many covariates (Delta inflow, exports, routing, predation, etc.) may affect the survival of salmonids and the evidence for a relationship with flow is more equivocal (**Buchanan et al. 2021, Buchanan et al. 2018, Buchanan and Skalski 2020)**.** Studies are hampered by correlation between environmental covariates, complicated routing, little experimental control, and (for Chinook salmon) overall low survival.
- **Juvenile salmonids outmigrating from the San Joaquin basin are particularly vulnerable to the hydrodynamic conditions, including export effects, in the south Delta since *all of them* experience those conditions (while only a portion of Sacramento basin fish may reach the south Delta):** All fish migrating from the San Joaquin basin (including threatened California Central Valley steelhead and SJRRP spring-run Chinook salmon) necessarily transit the south Delta given their entry point to the Delta. In a study of loss of coded-wire-tagged release groups at the export facilities, Zeug and Cavallo (2014) found that the relative loss of San Joaquin River releases was "more than double that of Sacramento River releases at both facilities…although relative loss was less than 5% for most releases; this value ranged as high as 17.5%".

Annotated References

- Buchanan, Rebecca A., Patricia L. Brandes, and John R. Skalski. 2018. Survival of Juvenile Fall-Run Chinook Salmon through the San Joaquin River Delta, California, 2010-2015. *North American Journal of Fisheries Management* 38: 663-679.
    - Analyzed the results of a multi-year study of through-Delta survival of acoustic-tagged **fall-run Chinook salmon released in the mainstem San Joaquin River** just upstream of the Delta. Through-Delta survival was low overall, with an estimate of just 2% in 2011, a very wet year. However, survival in a riverine reach did show better survival in the wet year (48%) compared to drier years (1-32%).

- Buchanan, R.A., and J.R. Skalski. 2020. Relating survival of fall-run Chinook Salmon through the San Joaquin Delta to river flow. *Environmental Biology of Fishes* 103: 389-410.

- Buchanan, Rebecca, Elissa Buttermore, and Joshua Israel. 2021. Outmigration Survival of a Threatened Steelhead Population through a Tidal Estuary. Canadian Journal of Fisheries and Aquatic Sciences. 78. 10.1139/cjfas-2020-0467.
    - Analyzed the results of a multi-year study of through-Delta survival of acoustic-tagged **steelhead released in the mainstem San Joaquin River** just upstream of the Delta**.** Through-Delta survival ranged from 6% to 69%, and was positively related to San Joaquin River inflow and to the I:E ratio. Note that this study also showed that through-Delta survival was positively related to CVP exports, though survival was negatively related to SWP exports alone, and to combined CVP and SWP exports.

- Cavallo, Brad, Phil Gaskill, and Jenny Melgo. 2013. Investigating the Influence of Tides, Inflows, and Exports on Sub-Daily Flow in the Sacramento-San Joaquin Delta. Cramer Fish Sciences report. 64 p.
- Henderson, Mark J., Ilysa S. Iglesias, Cyril J. Michel, Arnold J. Ammann, and David D. Huff. 2019.Estimating spatial–temporal differences in Chinook salmon outmigration survival with habitat- and predation-related covariates. *Canadian Journal of Fisheries and Aquatic Sciences*. 76(9): 1549-1561. https://doi.org/10.1139/cjfas-2018-0212
    - Five years (2007-2011) of acoustic telemetry data for 1,709 **late-fall Chinook salmon** smolts was used to evaluate the effect of habitat- and predation-related covariates on outmigration survival through the **Sacramento River**. Flow was the most important covariate in predicting outmigration success, with increased levels of annual flow correlating to increased smolt survival.
- Michel, Cyril & Notch, Jeremy & Cordoleani, Flora & Ammann, Arnold & Danner, Eric. (2021). Nonlinear survival of imperiled fish informs managed flows in a highly modified river. Ecosphere. 12. 10.1002/ecs2.3498.
    - Analyzed migration survival data from 2,436 acoustic-tagged juvenile **Chinook salmon** from studies spanning differing water years (2013–2019) and different runs (**spring-run, fall-run, and winter-run**) to evaluate the flow–survival relationship in the **Sacramento River**.
    - This relationship was best described by a step function, with three flow thresholds that we defined as minimum (4259 cfs), historic mean (10,712 cfs), and high (22,872 cfs). Survival varied by flow threshold: 3.0% below minimum, 18.9% between minimum and historic mean, 50.8% between historic mean and high, and 35.3% above high.

- Notch, J. J., A. S. McHuron, C. J. Michel, F. Cordoleani, M. Johnson, M. J. Henderson, and A. J. Ammann. 2020. Outmigration survival of wild Chinook salmon smolts through the Sacramento River during historic drought and high water conditions. Environmental Biology of Fishes 103: 561–576

    - From 2013 to 2017, 334 **spring-run smolts** were captured and acoustic tagged while out-migrating from Mill Creek. Cumulative survival of tagged smolts from Mill Creek through the **Sacramento River** (to the confluence with the Feather River, upstream of the Delta) was 9.5% (+/- 1.6) during the study, with relatively low survival during historic drought conditions in 2015 (4.9% +/- 1.6) followed by increased survival during high flows in 2017 (42.3% +/- 9.1).

- Zeug, Steven C. and Bradley J. Cavallo. 2014. Controls on the Entrainment of Juvenile Chinook Salmon (*Oncorhynchus tshawytscha*) into Large Water Diversions and Estimates of Population-Level Loss. PLoS ONE 9(7): e101479. https://doi.org/10.1371/journal.pone.0101479

The Salmon Technical Working Group (STWG), convened by the Collaborative Adaptive Management Team (CAMT), recently issued a report that reviewed some recent results from studies on salmonid survival in the South Delta (STWG 2024). One finding was that "after many years of intensive scientific investigation, we have not observed significant survival improvements for San Joaquin River-origin salmonids, nor have we seen an adverse impact from water export rates on survival under the range of regulatory and environmental conditions studied (e.g., OMR no more negative than -5,000 cfs. See Framing section for more detail)." NMFS emphasizes that the observed combinations of exports and San Joaquin River inflow during survival studies were likely subject to regulatory limits on OMR or inflow-to-export ratio. Therefore, inferences regarding export effects on survival must be limited to the incremental effects beyond the regulatory range. The STWG does acknowledge that their review of recent data "does not necessarily support an inference that existing regulatory tools that limit exports are ineffective," but goes on to say that their review "does suggest exports are not the primary factor negatively affecting survival of San Joaquin origin salmonids." NMFS considers the latter point insufficiently caveated.

Managing exports to reduce entrainment risk may negatively impact the survival of juvenile Chinook salmon utilizing the Old River route because it reduces the likelihood of being salvaged and trucked past the Delta. Because trucked fish, re-released in the western Delta would avoid a number of stressors along their migration path it is thought that survival may be higher for those fish. However, because the estimated loss of entrained salmonids is greater at the SWP (approximately 4.33 fish lost for every fish salvaged) compared to the CVP (approximately 0.68 fish lost for every fish salvaged), and the SWP has greater export capacity (and thus entrainment potential) than the CVP, it is important to consider that survival effects attributed to salvage may relate differently to SWP or combined exports than compared to CVP exports alone. For example, while no export factor was significant at the testwise level (alpha = 0.0042), Buchanan et al. (2021) found that the direction of effect on steelhead survival from the head of Old River to Chipps Island was positive for CVP exports but negative for SWP or combined SWP and CVP exports. However, in Buchanan and Skalski (2020), a similar analysis on Chinook salmon survival found a positive direction of effect on Chinook survival from the head of Old River to Chipps Island (again, within the range of variation beyond regulatory constraints) for both a CVP export term and a combined SWP and CVP export term. More studies and analyses of the effects of juvenile Chinook salmon and steelhead near the diversion facility intakes and northward in the OMR corridor are needed to determine what operational conditions (if any) can improve survival outcomes relative to entrainment and salvage.

- Salmon Technical Working Group. 2024. A Review of Recent Science to Improve Our Understanding and the Application of Life Cycle and Decision Support Models to Salmon Management in the South Delta. Report by Salmon Technical Working Group to the Collaborative Adaptive Management Team. 48 p.

SUPPLEMENTAL REFERENCES

This appendix is a compilation of multiple literature reviews, most of which include full citations not repeated here. The exception is the Six-year Study Briefing portion of the appendix, for which full citations are provided below.

U.S. Bureau of Reclamation (USBR). 2018. NMFS Biological Opinion RPA IV.2.2: 2011 Six-Year Acoustic Telemetry Steelhead Study. Contributions by Buchanan, R., J. Israel, P.Brandes. E. Buttermore. Reclamation Bay-Delta Office, Mid-Pacific Region, Sacramento, CA. FINAL REPORT May 14, 2018, 144p.

U.S. Bureau of Reclamation (USBR). 2018. NMFS Biological Opinion RPA IV.2.2: 2012 Six-Year Acoustic Telemetry Steelhead Study. Contributions by Buchanan, P. Brandes, R., J. Israel, E. Buttermore. Reclamation Bay-Delta Office, Mid-Pacific Region, Sacramento, CA. FINAL REPORT May 16, 2018, 172p. Includes errata from June 13, 2018.

U.S. Bureau of Reclamation (USBR). 2018. NMFS Biological Opinion RPA IV.2.2: 2013 Six-Year Acoustic Telemetry Steelhead Study. Contributions by: R. Buchanan, P. Brandes, J. Israel, and E. Buttermore. U.S. Bureau of Reclamation. Bay-Delta Office, Mid-Pacific Region, Sacramento, CA. FINAL REPORT. June 2018, 213 pp.

U.S. Bureau of Reclamation (USBR). 2018. OCAP 2014 Steelhead Tagging Study: Statistical Methods and Results. Prepared for Joshua Israel, U.S. Bureau of Reclamation, Sacramento, CA. Prepared by: Rebecca Buchanan, Columbia Basin Research, School of Aquatic and Fishery Sciences, University of Washington, Seattle, WA. May 2, 2018. 158 pp.

Programmatic Biological Opinion for the Reinitiation of Consultation on the Long-Term Operation of the Central Valley Project and State Water Project

Appendix C:

Estimate of Change in Abundance of Central Valley Chinook Salmon Available to Southern Resident Killer Whales Under the Proposed Action

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C-1. Estimate of Change in Abundance of Central Valley Chinook Salmon Available to Southern Resident Killer Whales Under the Proposed Action

This assessment evaluates the abundance of Chinook salmon produced from the Central Valley (CV) watershed of California and available as adults in the ocean as prey for Southern Resident killer whales (SRKWs). The assessment assumes that age 3 and older Chinook salmon would be in the size range most suitable as prey, so the assessment focuses on age 3+ Chinook salmon.

Table 1 depicts portions of life stages differentially affected by the proposed action phases and other relevant scenarios that have quantitative models available and are compatible with the CalSim 3 water operations simulation. Unquantified effects are described but not bundled into the evaluation of abundance and assumed to apply equally across scenarios. The quantified freshwater mortality sources are aggregated into an overall change in freshwater survival attributable to the water operations scenarios.

Hatchery Chinook salmon releases are included in the analysis by using the average annual number of Chinook salmon released for all hatcheries by run. Releases are separated by in-river and San Francisco Bay (Bay) releases using the proportion of release locations for each hatchery over the past 15 years or so. Year-to-year variation in release location and numbers occurs in response to environmental conditions and hatchery management flexibility. For example, recently fry releases occurred in addition to the standard release numbers and these fry releases were not included here. In-river mortality based on the XT model and modeled with the Delta Passage Model was applied to the in-river released hatchery fish and these were then added to the Bay releases for a total number of hatchery fish in the Bay. The past 22-year median ocean Chinook salmon abundance is divided by the hatchery and naturally produced Chinook salmon in the Bay to determine a baseline bay to ocean survival value. The hatchery proportion is based on coded wire tag recovery data in 2011–2020 from escapement surveys on the spawning grounds and proportions in the ocean are assumed to be the same. The past 22-year median ocean abundance along with differences in freshwater survival from the No Action Alternative (NAA) was used to calculate a point value of Chinook salmon available as prey to SRKWs under each modeled scenario. The NAA was used as a point of reference in the first step of the methodology to obtain relative differences in survival between all the scenarios.

Table 1. Rivers and Chinook salmon runs assessed and models used in the assessment. The "Run" column refers to natural-origin (i.e., spawned in-river) fish unless stated otherwise. The proportions of Central Valley Chinook salmon are the mean 2001–2017 production from each tributary in U.S. Fish and Wildlife Service (2018).

River	Run	Model	Proportion of Central Valley Chinook salmon	Reach shown in Figure 1
Sacramento (spawning)	Fall	Salmon	0.097	1
Sacramento (Red Bluff Diversion Dam to Delta Cross Channel)	Fall	XT	0.097	2
Sacramento (spawning)	Late Fall	Salmon	0.026	1
Sacramento	Late Fall (Red Bluff Diversion Dam to Delta Cross Channel)	XT	0.026	2
Sacramento	Winter	CVPIA SIT	0.014	Central Valley-wide
Central Valley	Spring	CVPIA SIT	0.02	Central Valley-wide
Clear Creek	Fall	Upstream effects not included	0.023	
Feather	Fall	Upstream effects not included	0.240	
American	Fall	Salmon	0.223	3
American (mouth to Delta Cross Channel)	Fall	XT	0.223	4
Stanislaus	Fall	Upstream effects not included	0.010	
Delta	All Chinook salmon from Sacramento River basin	Delta Passage Model	0.936	5
Delta	Fall-run Chinook salmon from San Joaquin River basin and Delta East Side streams[a]	Unquantified	0.065	
Hatchery instream releases	All runs	XT model and Delta Passage Model NAA scenario	0.59 of hatchery releases	3,4,5
Hatchery Bay releases	All Bay releases	No project effects assumed	0.41 of hatchery releases	

[a] "Delta East Side streams" refers to the Cosumnes River, Mokelumne River, and Calaveras River.

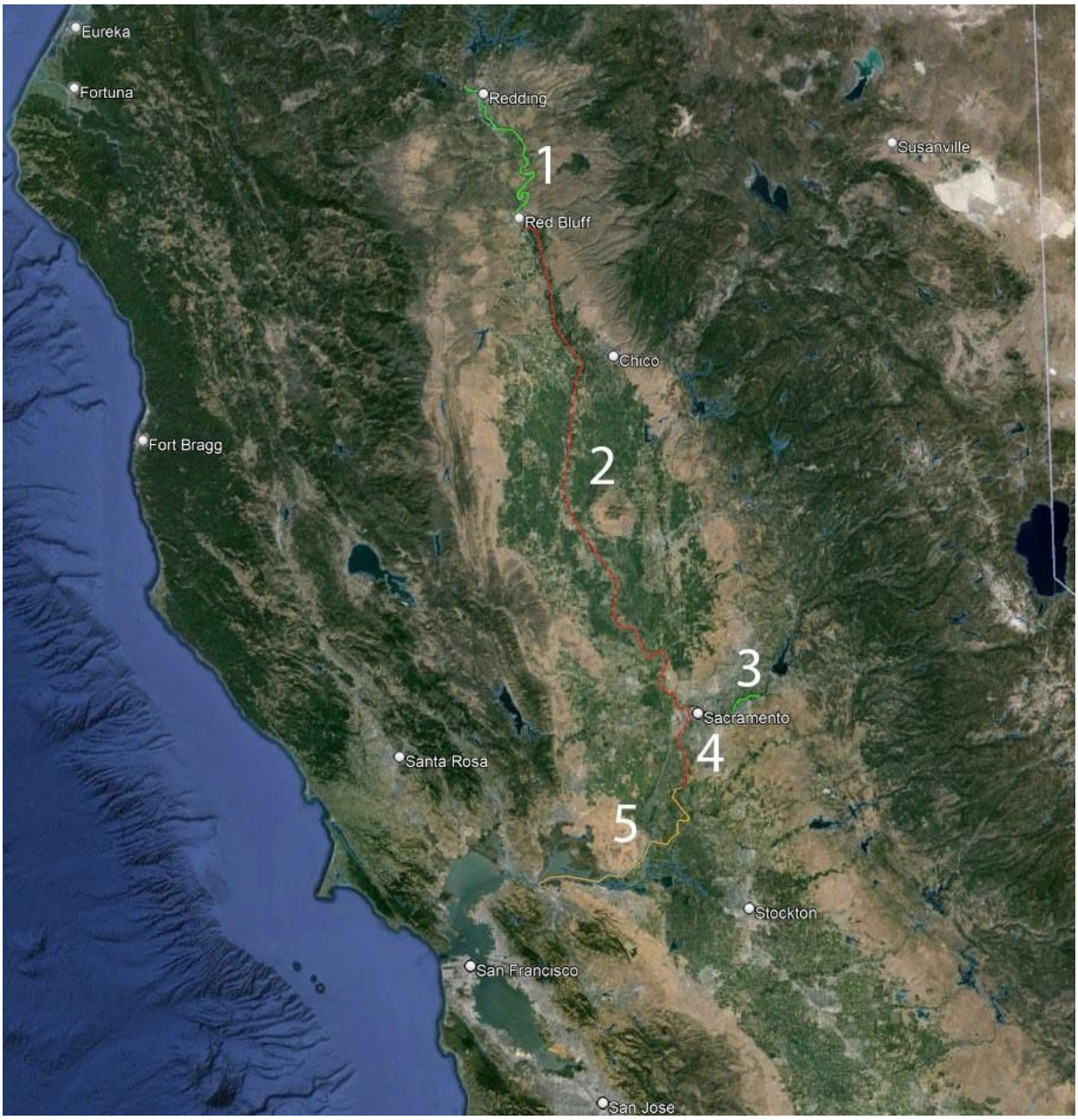


Figure 1. Reaches covered by models in Table 1

C-1.1 Changes in Chinook Salmon Survival and Production From the Upstream Areas

C-1.1.1 Sacramento River

The Central Valley Project Improvement Act (CVPIA) Science Integration Team (SIT) life cycle model was used to estimate the abundance of juvenile Sacramento River (SR) winter-run Chinook salmon and CV spring-run Chinook salmon.

The Salmon egg mortality model (California Department of Water Resources [DWR] and U.S. Bureau of Reclamation [Reclamation] 2016) was used to estimate the change in survival in fall-

run and late fall-run Chinook salmon in the Sacramento River from changes in early life-stage survival attributable to water temperature. This model uses the water temperature model outputs along with Chinook salmon spawning timing, distribution, and abundance to estimate water temperature effects to pre-spawned eggs, incubating eggs, and alevins.

The XT model was used to estimate survival of juvenile fall-run and late fall-run Chinook salmon migrating down the Sacramento River between Red Bluff and the Delta Cross Channel. The model estimates survival based on estimated travel time and predation rates from acoustic tagged and tracked hatchery late fall-run Chinook salmon releases.

C-1.1.1.1 Fall-Run Chinook Salmon

Figure 2 and Table 2 show the Salmon results for fall-run Chinook salmon in the Sacramento River. Median mortality is around 40 percent in each of the three Alternative 2 operating scenarios (Alt2v1, Alt2v2, and Alt2v3). Alternative 2 scenarios show variation with different precipitation patterns and storage levels between years.

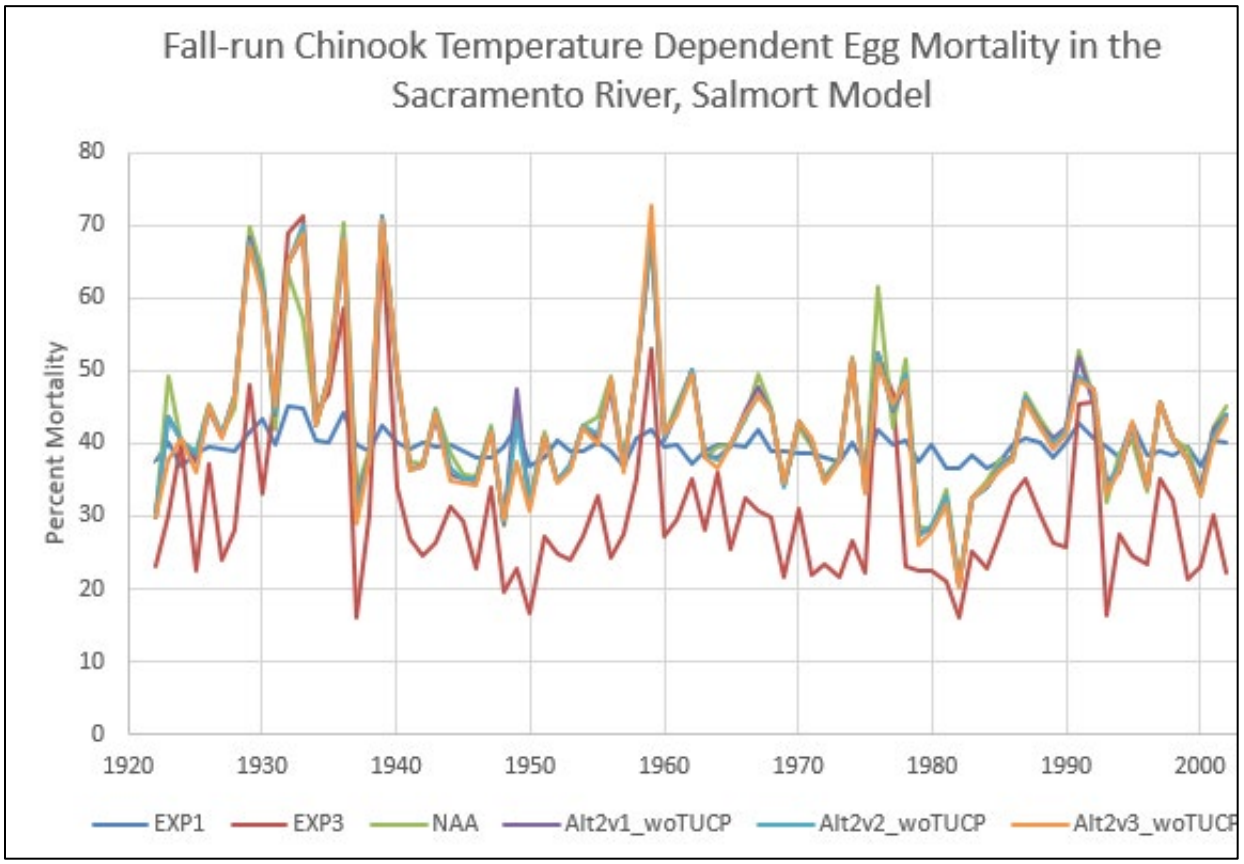


Figure 2. Fall-run Chinook salmon temperature-dependent egg mortality in the Sacramento River from the Salmon Model.

Source: (Reclamation 2023-2024).

Table 2. Fall-run Chinook salmon temperature-dependent egg mortality in the Sacramento River from the Salmon Model.

	EXP1	EXP3	NAA	Alt2v1_woTUCP	Alt2v2_woTUCP	Alt2v3_woTUCP
Median	39.5	27.4	41.2	41.0	41.1	40.7
Maximum	45.2	71.2	70.7	71.2	71.3	72.8
Minimum	36.5	16.1	21.0	20.3	20.4	20.3

Source: (Reclamation 2023-2024).

Figure 3 and Table 3 show fall-run Chinook salmon migration survival from Red Bluff down to the Delta Cross Channel from the XT model. The XT model describes the probability of predator-prey encounters as a function of the predator density and the movement patterns of predators and prey. Survival estimates were similar between high and low flow conditions while fish travel time had a higher variability. Survival in each of the Alternative 2 operating scenarios was nearly the same.

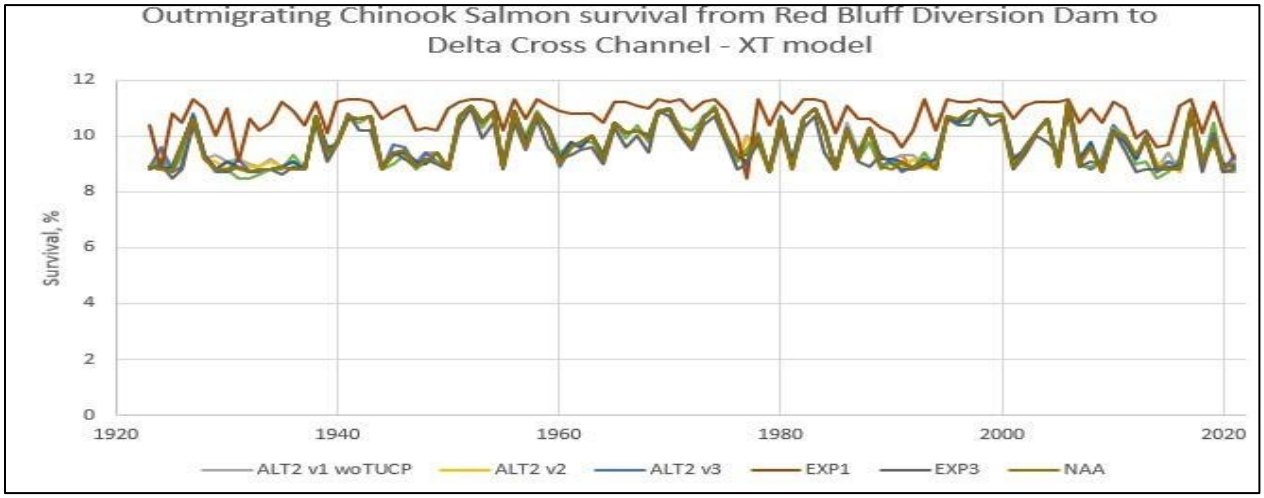


Figure 3. Fall-run and late fall-run Chinook salmon survival between Red Bluff and the Delta Cross Channel from the XT model.

Source: (Reclamation 2023-2024).

Table 3. Fall-run and late fall-run Chinook salmon survival between Red Bluff and the Delta Cross Channel from the XT model.

	ALT2 v1 woTUCP	ALT2 v2	ALT2 v3	EXP1	EXP3	NAA
Median	9.7	9.6	9.6	11	9.3	9.6
Maximum	11.2	11.2	11.2	11.3	11	11.2
Minimum	8.7	8.7	8.7	8.5	8.5	8.7

Source: (Reclamation 2023-2024).

C-1.1.1.2. Late Fall-Run Chinook Salmon

Temperature-dependent egg mortality for late fall-run Chinook salmon in the Sacramento River from the Salmon model was about the same under each of the Alternative 2 operating scenarios and the EXP3 scenario with a median mortality rate of about 6.5 percent (Figure 4 and Table 4).

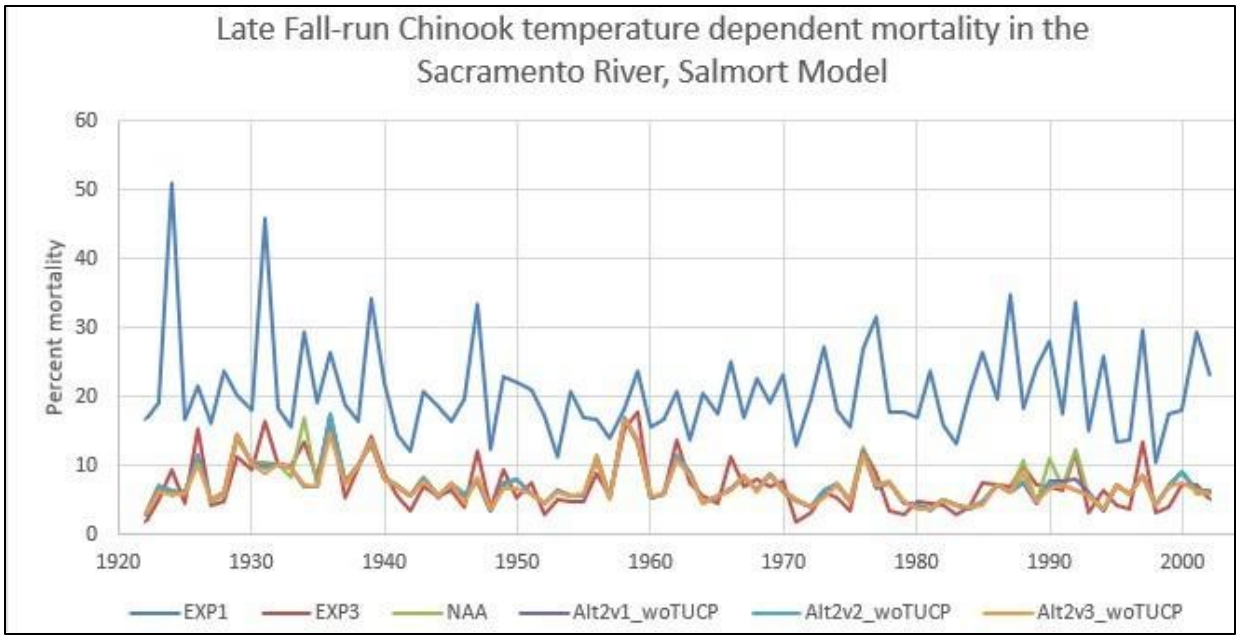


Figure 4. Late fall-run Chinook salmon temperature-dependent egg mortality in the Sacramento River from the Salmon model.

Source: (Reclamation 2023-2024).

Table 4. Late fall-run Chinook salmon temperature-dependent egg mortality in the Sacramento River from the Salmon model.

	EXP1	EXP3	NAA	Alt2v1_woTUCP	Alt2v2_woTUCP	Alt2v3_woTUCP
Median	19.0	6.3	6.5	6.6	6.5	6.4
Maximum	51.1	17.6	17.6	17.3	17.4	16.7
Minimum	10.3	1.7	2.9	2.9	2.9	2.9

Source: (Reclamation 2023-2024).

C-1.1.1.3. Central Valley Spring-Run Chinook Salmon

Populations of CV spring-run Chinook salmon are primarily in the cooler Sacramento River tributaries, and spawning in the mainstem Sacramento River has become a rarely documented event despite regular aerial spawning surveys. Since the gates at Red Bluff Diversion Dam were permanently lifted, population estimates for CV spring-run Chinook salmon in the mainstem are based primarily on redds observed during September during aerial redd surveys. The water

temperature management focus on SR winter-run Chinook salmon, which generally ends by the end of October, usually results in a water temperature increase during the CV spring-run Chinook salmon incubation period in the fall, which may limit the ability of CV spring-run Chinook salmon to successfully reproduce in the mainstem. In many years, no spawning is documented during the CV spring-run Chinook salmon spawning period (considered to be September in the Sacramento River). The CVPIA SIT model was used to estimate CV spring-run Chinook salmon juvenile abundance leaving the Bay; sources of mortality are not partitioned out for specific tributaries, life stages, or locations. Juvenile abundance is summed with the other runs in the Bay.

C-1.1.1.4. Sacramento River Winter-Run Chinook Salmon

Effects of the proposed action on SR winter-run Chinook salmon relative abundance throughout their life cycle were quantified using the CVPIA SIT SR winter-run Chinook salmon model. The SR winter-run Chinook salmon model was run both deterministically (i.e., no variability in parameters) and stochastically, to estimate demographic parameters, spawner abundances, and population trends for the period from 1980 to 1999 using flow and temperature inputs for each modeled alternative. In the Upper Sacramento River, the model integrates the effects of water temperature, flow, fish abundance, and habitat availability to arrive at production of juvenile SR winter-run Chinook salmon emigrating down the Sacramento River, through the Delta to the ocean. Ocean survival factors are included through the range of years in the ocean until the fish come back and spawn. Figure 5 and Figure 5 show how the juvenile abundance responds to the water operations and other factors over the 20-year period, 1981–2000, used in the model. The abundance displayed is that of juveniles exiting at the Golden Gate Bridge (Figure 5 and Table 5). Results are generally similar for each of the Alternative 2 operating scenarios. The juvenile abundance is added to the other runs in the Bay.

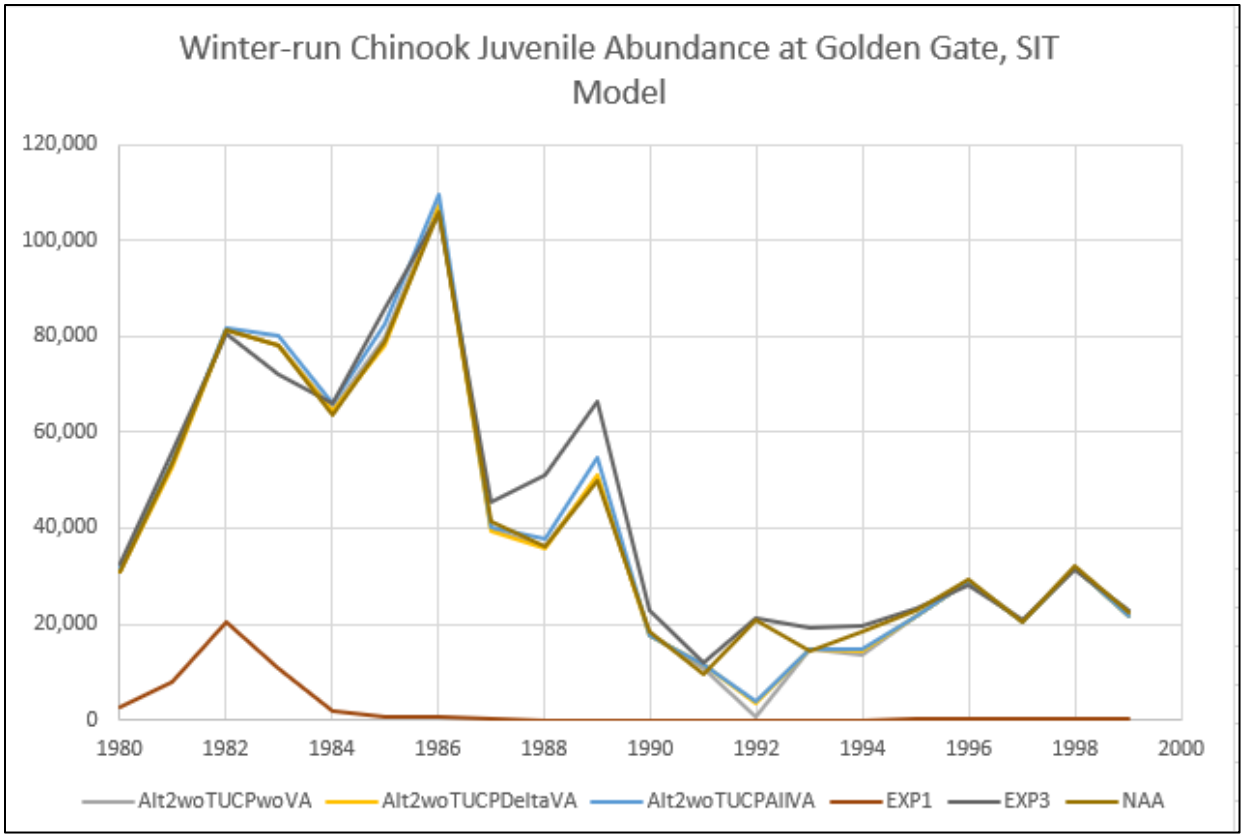


Figure 5. Sacramento River winter-run Chinook salmon juvenile abundance at the Golden Gate Bridge from the CVPIA SIT model.

Source: (Reclamation 2023-2024).

Table 5. Sacramento River winter-run Chinook salmon juvenile abundance at the Golden Gate Bridge from the CVPIA SIT model.

	Alt2woTUCPwoVA	**Alt2woTUCPDeltaVA**	**Alt2woTUCPAllVA**	**EXP1**	**EXP3**	**NAA**
Median	31,297	31,425	31,764	76	31,821	31,397
Maximum	107,615	107,330	109,691	20,427	105,649	105,948
Minimum	559	3,556	3,854	1	11,740	9,367
Mean	40,248	40,304	41,312	2,278	44,123	41,404

Source: (Reclamation 2023-2024).

C-1.1.2. Clear Creek

No models were available to assess survival in Clear Creek. Clear Creek fall-run Chinook salmon are added in with other Sacramento River runs and survival included with them down the Sacramento River from the XT model.

C-1.1.3. Lower American River

C-1.1.3.1. Fall-Run Chinook Salmon

The Salmon egg mortality model (DWR and Reclamation 2016) was used to estimate the change in survival in the American River from changes in early life stage survival attributable to water temperature. This model uses the water temperature model outputs along with Chinook salmon spawning distribution and abundance to estimate water temperature effects to pre- spawned eggs, incubating eggs, and alevins. The Lower American River is a water temperature- challenged system for salmonids and maintaining a balance in management for steelhead, fall- run Chinook salmon, and other water management needs results in tradeoffs in water temperatures and flows for the maintenance of habitat conditions hospitable to salmonids. Temperature-related egg mortality is around 27 percent under each of the Alternative 2 operating scenarios (Figure 6 and Table 6).

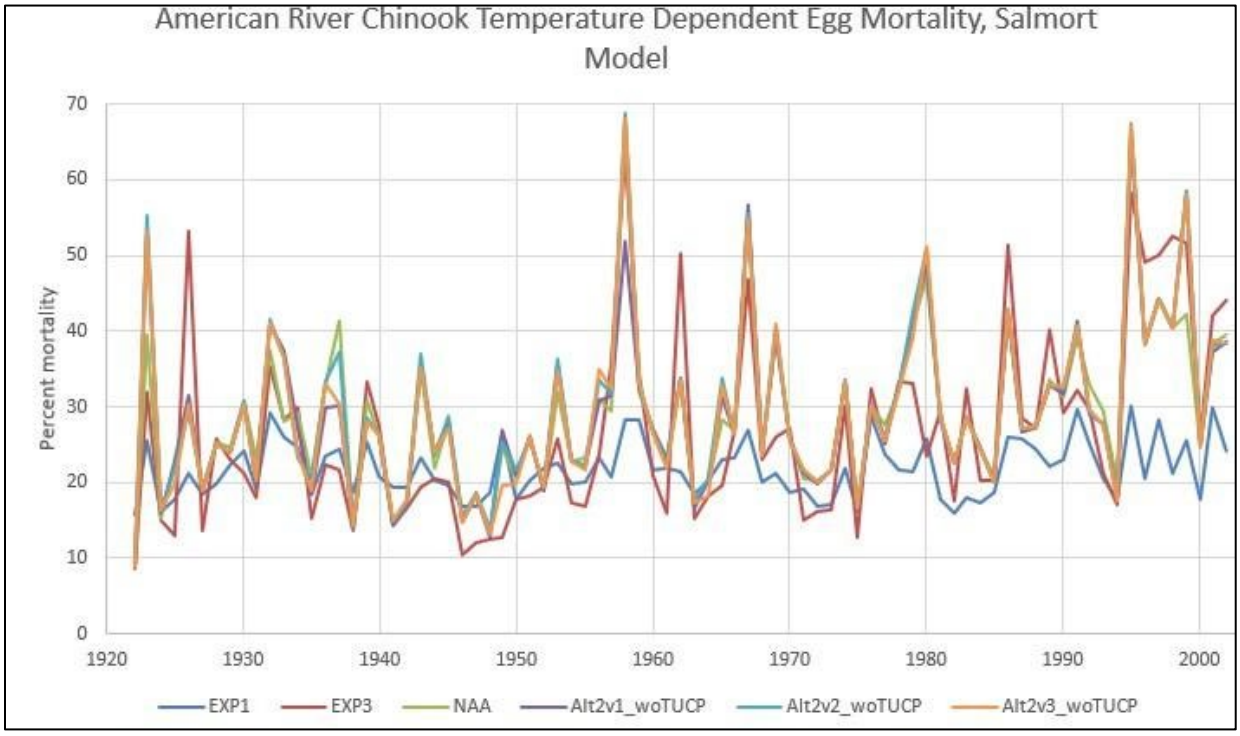


Figure 6. Annual temperature-related mortality of Chinook salmon eggs in the American River from the Salmon model.

Source: (Reclamation 2023-2024).

Table 6. Annual temperature-related mortality of Chinook salmon eggs in the American River from the Salmon model.

	EXP1	EXP3	NAA	Alt2v1_woTUCP	Alt2v2_woTUCP	Alt2v3_woTUCP
Median	21.3	23.6	27.5	27.1	27.2	27.2
Maximum	30.0	64.0	68.1	65.6	68.9	68.1
Minimum	15.8	8.7	8.9	8.9	9.1	8.9

Source: (Reclamation 2023-2024).

Pre-spawning mortality of fall-run Chinook salmon in the Lower American River is the highest measured in any of the CV rivers (Figure 7). This is partially depicted in the annual egg mortality estimates in Figure 6 and Table 6 but not fully. Water temperatures are in a stressful range for adult holding (mid 60s) in most years and the fall-run Chinook salmon congregate near Nimbus Dam starting in summer and peaking in October to November when spawning starts. During wetter years, such as 2011, when flows are higher and water is cooler throughout the fall, the fish are distributed more evenly throughout the river and are more actively moving around and redistributing in advance of spawning in comparison with most years when the majority hold at the dam. Water temperatures are relatively unchanged between action scenarios so appreciable changes in the extent of pre-spawning mortality are not expected (Figure 8).

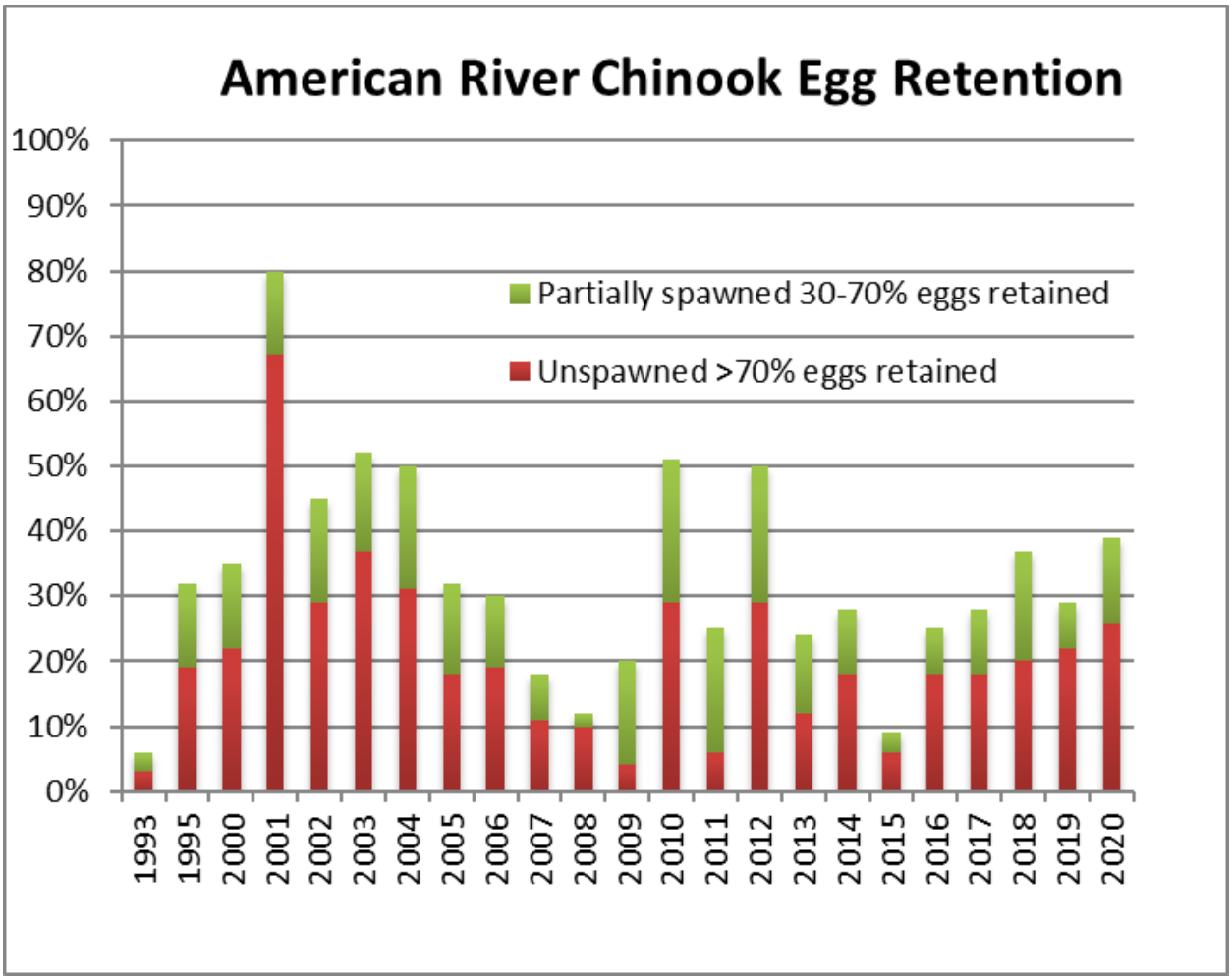


Figure 7. Egg retention in American River Chinook salmon, 1993–2020. Note: no data for 1996–1999. Data compiled from annual CDFW escapement reports.

Source: (Reclamation 2023-2024).

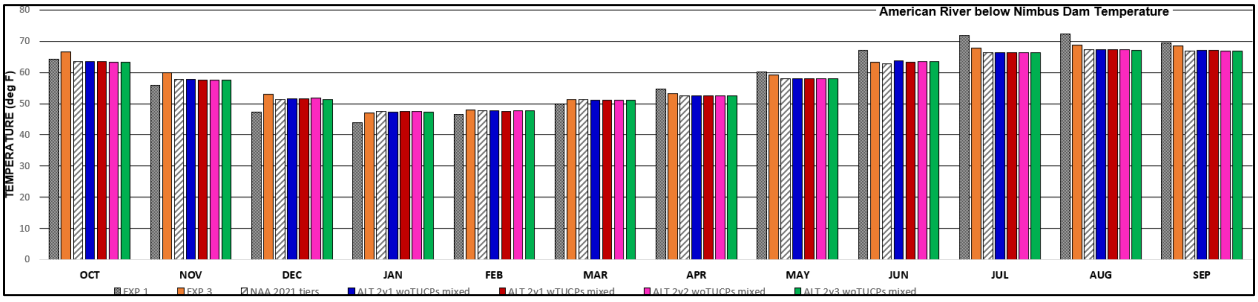


Figure 8. American River below Nimbus Dam monthly water temperature at the 50-percent exceedance probability.

Source: (Reclamation 2023-2024).

C-1.1.4. Feather River

Upstream effects were not evaluated for the Feather River because operations are governed by the Federal Energy Regulatory Commission (FERC) license within that project area. Migration for Feather River salmon through the Delta is assessed with the Delta Passage Model described in the Delta section below.

C-1.1.5. Stanislaus River

C-1.1.5.1. Fall-Run Chinook Salmon

Survival from the Stanislaus River was not included because no models are available to assess survival from the San Joaquin River system to the Bay. The proportion of CV Chinook salmon abundance from the San Joaquin tributaries and Mokelumne River was added to the juveniles in the Bay and included in the adult ocean abundance estimate.

Through-Delta survival of juvenile Chinook salmon emigrating from the San Joaquin River basin has been estimated to be less than 5 percent (Buchanan 2017). This low migratory survival is likely a key factor limiting natural populations in the Stanislaus River and other San Joaquin tributaries. March through June flows in the Stanislaus River are similar between Alternative 2 operating scenarios, so survival potential should be similar (Figure 9). Stanislaus River Chinook salmon production comprises about 1 percent of the CV total.

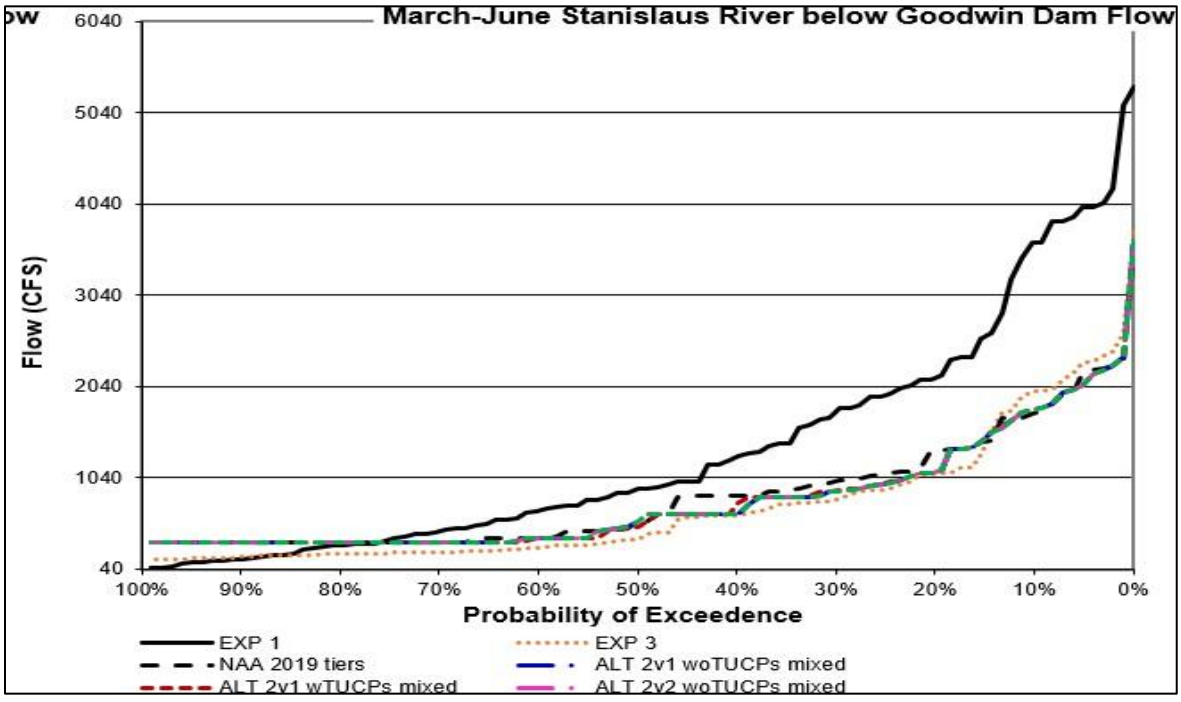


Figure 9. March through June Stanislaus River flow below Goodwin Dam.

Source: (Reclamation 2023-2024).

C-1.1.5.2. Central Valley Spring-Run Chinook Salmon

Because few CV spring-run Chinook salmon are expected on the Stanislaus River, no assessment of Alternative 2 operating scenario-related effects was conducted as part of this evaluation of Chinook salmon production for SRKW prey.

C-1.1.6. Delta

C-1.1.6.1. Sacramento River Basin Chinook Salmon

The Delta Passage Model (Cavallo et al. 2011) was used to estimate survival of Chinook salmon from the Sacramento River basin emigrating through the Delta. This model uses results from acoustic tagged salmon survival studies along with relationships between flow through Delta channels and survival to estimate through-Delta smolt survival. Figure 10 and Figure 11 and Table 7 and Table 8 show Delta Passage Model results for fall-run and late fall-run Chinook salmon from the Sacramento River basin. Results for both runs show median survivals from 0.17 to 0.2.

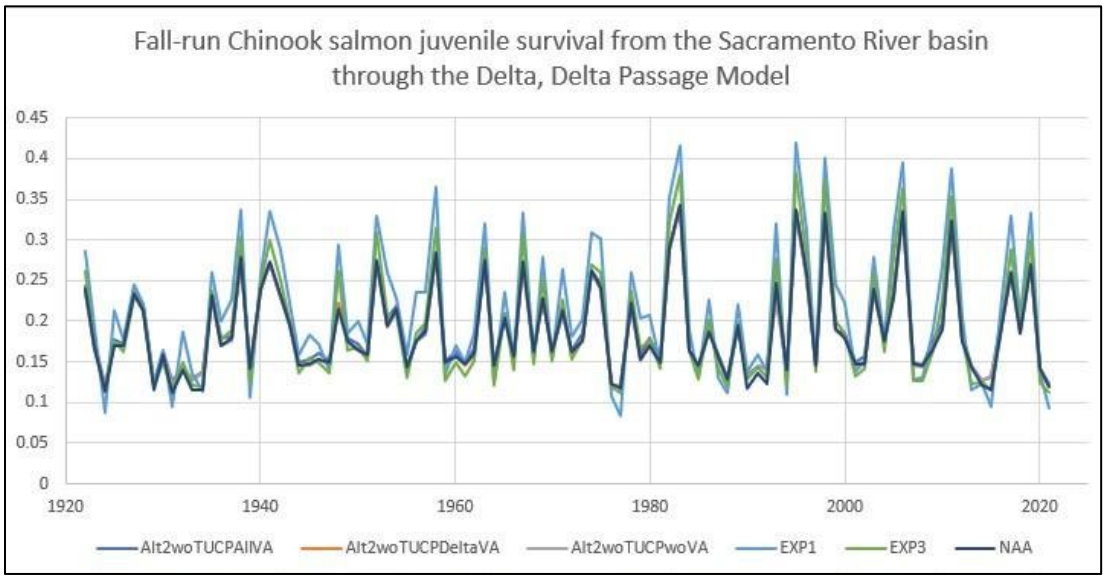


Figure 10. Delta Passage Model results for fall-run Chinook salmon.

Source: (Reclamation 2023-2024).

Table 7. Delta Passage Model results for fall-run Chinook salmon.

	Alt2woTUCPAllVA	Alt2woTUCPDeltaVA	Alt2woTUCPwoVA	EXP1	EXP3	NAA
Median	0.18	0.17	0.17	0.20	0.17	0.17
Maximum	0.34	0.34	0.34	0.42	0.38	0.34
Minimum	0.12	0.12	0.12	0.08	0.11	0.11

Source: (Reclamation 2023-2024).

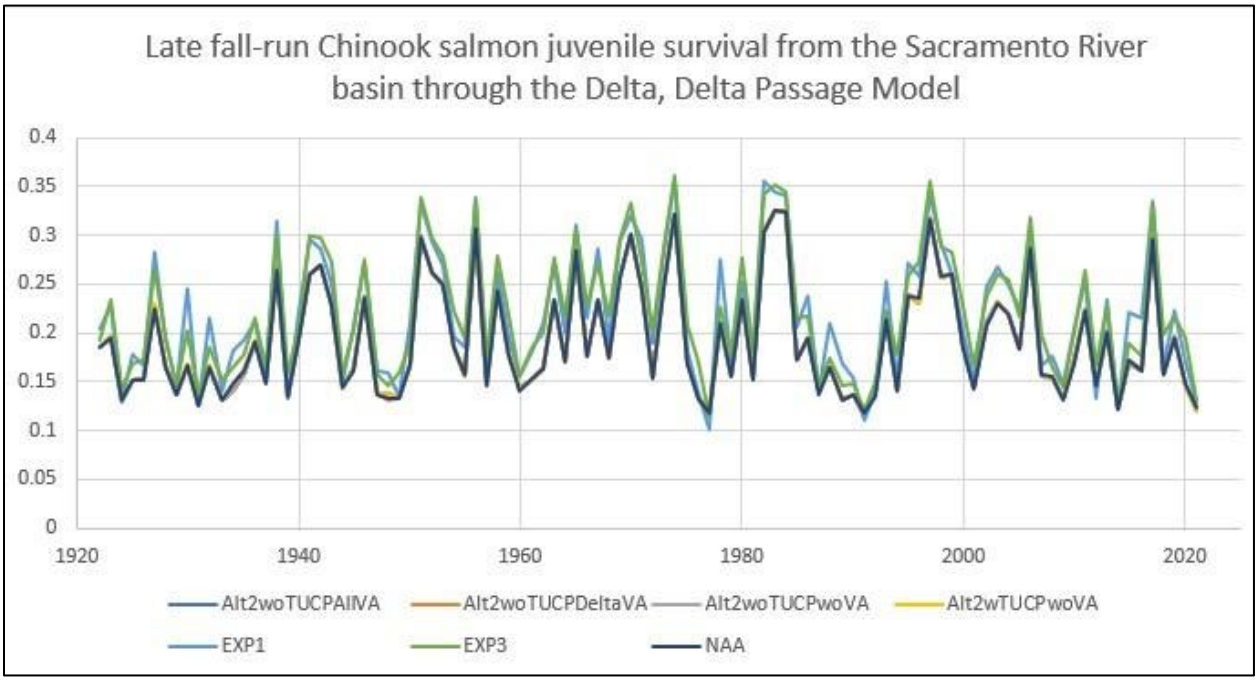


Figure 11. Delta Passage Model results for late fall-run Chinook salmon.

Source: (Reclamation 2023-2024).

Table 8. Delta Passage Model results for late fall-run Chinook salmon.

	Alt2woTUCPAllVA	Alt2woTUCPDeltaVA	Alt2woTUCPwoVA	EXP1	EXP3	NAA
Median	0.17	0.17	0.17	0.21	0.21	0.17
Maximum	0.33	0.33	0.33	0.36	0.36	0.33
Minimum	0.11	0.11	0.12	0.10	0.11	0.12

Source: (Reclamation 2023-2024).

C-1.1.6.2. San Joaquin River Basin and Mokelumne River Chinook Salmon

No Delta survival changes were incorporated for Chinook salmon from the San Joaquin or Mokelumne rivers. Chinook salmon from the San Joaquin tributaries comprise 2.6 percent and from the Mokelumne River comprise about 2.8 percent of the CV total.

Naturally Produced Chinook Salmon Survival to the Delta

Table 9 summarizes the survival values as a proportion of the NAA for each river and model presented previously and used in the quantitative assessment. Values greater than 1.0 indicate higher upstream survival relative to the NAA and values less than 1.0 indicate lower survival than the NAA. The proportion that each river and run comprises of the CV Chinook salmon abundance in the ocean over the 2001–2017 period (mean value) as estimated by the U.S. Fish and Wildlife Service (2018) is used to scale the survival value in each watershed and run to the total CV abundance.

Table 9. Upstream survival in each scenario as a proportion of survival in the no action alternative.

River and run	**Upstream effects - Egg Mortality Model**					**Upstream effects (Migration; mean difference) - XT Model**					**Proportion of Central Valley Abundance**
	EXP1	EXP3	Alt2v1	Alt2v2	Alt2v3	EXP1	EXP3	Alt2v1	Alt2v2	Alt2v3	
Sacramento River winter-run	Uses SIT Lifecycle Model										0.014
Sacramento River spring-run	Uses SIT Lifecycle Model										0.0003
Sacramento River fall-run	1.0201	1.1192	1.0038	1.0029	1.0051	1.0104	0.9982	1.0008	1.0001	1.0002	0.097
Sacramento River late fall-run	0.8830	1.0067	1.0008	1.0003	1.0006	1.0104	0.9982	1.0008	1.0001	1.0002	0.026
Clear Creek fall-run						1.0104	0.9982	1.0008	1.0001	1.0002	0.023
American River fall-run	1.0554	1.0222	1.0009	0.9987	1.0008	0.9971	1.0002	1.0000	1.0000	0.9999	0.22
Stanislaus River fall-run	not evaluated										0.099
Feather River fall-run						0.9971	1.0002	1.0000	1.0000	0.9999	0.24
Other Sac Runs (spring)	included in SIT model										0.022
Other Sac Runs (fall)	only Delta passage evaluated										0.29
San Joaquin Basin	not evaluated										0.026
Mokelumne	not evaluated										0.028

Survival Through the Delta

The Delta Passage Model results from Figure 10 and Figure 11 and Table 7 and Table 8 are aggregated for all rivers and runs from the Sacramento Basin passing through the Delta (Table 10). Results are multiplied by the upstream survival for each river for an aggregate freshwater survival. Results from each river are scaled by the proportion of CV production from each area to allow summing results across rivers for an aggregate freshwater survival as a proportion of NAA survival (Table 11).

Table 10. Survival through the delta from the Delta Passage Model for fall and late fall-run and life cycle effects from the SIT model for winter-run and spring-run Chinook salmon.

River and run	**Delta effects - Delta Passage Model**					**Life Cycle effects - SIT Model**					**Proportion of Central Valley Abundance**
	EXP1	EXP3	Alt2v1	Alt2v2	Alt2v3	EXP1	EXP3	Alt2v1	Alt2v2	Alt2v3	
Sacramento River winter-run	SIT model results presented as absolute median juvenile abundance					76	31,821	31,297	31,425	31,764	0.014
Sacramento River spring-run	SIT model results presented as absolute median juvenile abundance					76,490	74,138	73,040	73,139	73,199	0.0003
Sacramento River fall-run	1.0243	1.0048	1.0025	0.9994	0.9989						0.097
Sacramento River late fall-run	1.0268	1.0290	1.0003	1.0002	1.0002						0.026
Clear Creek fall-run	1.0243	1.0048	1.0025	0.9994	0.9989						0.023
American River fall-run	1.0243	1.0048	1.0025	0.9994	0.9989						0.22
Stanislaus River fall-run											0.099
Feather River fall-run	1.0243	1.0048	1.0025	0.9994	0.9989						0.24
Other Sac Runs (spring)	Included in SIT model										0.022
Other Sac Runs (fall)	1.0243	1.0048	1.0025	0.9994	0.9989						0.29
San Joaquin Basin	Not evaluated										0.026
Mokelumne	Not evaluated										0.028

Table 11. Freshwater survival by run scaled by proportion of Central Valley abundance and then summed to aggregate freshwater survival relative to a survival of 1.0 for the no action alternative (NAA). Values in the last row greater than 1.0 have higher abundance and survival than the NAA and values less than 1.0 are lower than the NAA.

Upstream and Delta	**Values scaled to Central Valley-wide proportion**				
	EXP1	**EXP3**	**Alt2v1**	**Alt2v2**	**Alt2v3**
Sacramento River winter-run	To be added in at the Bay from lifecycle model results				
Central Valley spring-run	To be added in at the Bay from lifecycle model results				
Sacramento River fall-run	0.10239	0.10886	0.09767	0.09722	0.09739
Sacramento River late fall-run	0.02376	0.02682	0.02599	0.02596	0.02597
American River fall-run	0.24066	0.22937	0.22403	0.22285	0.22318
San Joaquin and Mokelumne	0.08645	0.08645	0.08645	0.08645	0.08645
Feather River fall-run	0.24479	0.24089	0.24028	0.23955	0.23940
Other Sac Tribs - fall	0.29858	0.29290	0.29223	0.29134	0.29118
Upstream survival compared to NAA	0.99663	0.98530	0.96665	0.96338	0.96357

Hatchery-Produced Chinook Salmon

Hatchery-produced Chinook salmon releases are included in the analysis by using the average release of hatchery juveniles for 2007–2013 (from Palmer-Zwahlen et al. 2018 and 2019, and Palmer Zwahlen and Kormos 2015). The proportion of hatchery fish released in-river and in the Bay varies from year to year based on water year conditions and other factors. The general release goals and release locations based on recent trends over the last 15 years (Table 12) were used to estimate an average in-river release proportion of 0.59.

Table 12. Central Valley Chinook salmon hatchery release goals and proportion released in-river and in Bay areas.

Hatchery annual Chinook salmon releases	General goal	Proportion Bay	Proportion in-river	Number in-river
Coleman fall	12,000,000	0	1	12,000,000
Coleman late fall	1,000,000	0	1	1,000,000
Livingston Stone winter	200,000	0	1	200,000
Feather fall	6,000,000	0.7	0.3	1,800,000
Feather spring	2,000,000	0.5	0.5	1,000,000
Feather enhancement	2,000,000	1	0	0
Nimbus	4,000,000	0.33	0.67	2,680,000
Mokelumne	5,000,000	0.7	0.3	1,500,000
Mokelumne enhancement	2,000,000	1	0	0
Merced	300,000	0	1	300,000
Total release	34,500,000			
In-river release	20,480,000			
Proportion released in-river	0.59			

In-river mortality was applied to all the in-river released hatchery fish using the in-river survival probabilities under each scenario estimated in Table 9 and Table 10 based on the location and timing of release. In this methodology, the first step was to apply the median survival estimates under each operating scenario from the XT model (Figure 3 and Table 3) to Coleman and Livingston Stone hatchery in-river releases. The XT model difference between the median survival estimates under each operating scenario from the Red Bluff Diversion Dam to the Delta Cross Channel and the Red Bluff Diversion Dam to the American River was applied to American River, Mokelumne River, Feather River, and Merced Hatchery in-river releases. The median Delta Passage Model survival estimate under each operating scenario was applied to all the hatchery fish passing through the Delta (Table 7 and Table 8). We assumed that the Mokelumne and Merced hatchery survival through the Delta (along with their in-river survival) would be similar to the Delta Passage Model survival for Sacramento River origin Chinook salmon. The in-river released hatchery Chinook salmon surviving through the Delta were added to the Bay releases for a total number of hatchery fish in the Bay (Table 13).

Table 13. Calculation of median estimate of hatchery Chinook salmon in the Bay.

					Upstream Effects (Migration; median difference) - XT Model						Delta Effects - Delta Passage Model					
Hatchery	Run Timing	Location	In-River Releases	Bay Releases	EXP1	EXP3	NAA	Alt2v1	Alt2v2	Alt2v3	EXP1	EXP3	NAA	Alt2v1	Alt2v2	Alt2v3
Coleman	Fall	Sacramento River	12,000,000	0	0.11	0.09	0.10	0.10	0.10	0.10	0.20	0.17	0.17	0.18	0.17	0.17
Coleman	Late Fall	Sacramento River	1,000,000	0	0.11	0.09	0.10	0.10	0.10	0.10	0.21	0.21	0.17	0.33	0.33	0.33
Livingston Stone	Winter	Sacramento River	200,000	0	0.11	0.09	0.10	0.10	0.10	0.10	0.20	0.17	0.17	0.18	0.17	0.17
Feather	Fall	American River	1,800,000	4,200,000	0.96	0.96	0.96	0.96	0.96	0.96	0.20	0.17	0.17	0.18	0.17	0.17
Feather	Spring	American River	1,000,000	1,000,000	0.96	0.96	0.96	0.96	0.96	0.96	0.20	0.17	0.17	0.18	0.17	0.17
Feather Enhancement	Fall	American River	0	2,000,000												
Nimbus	Fall	American River	2,680,000	1,320,000	0.96	0.96	0.96	0.96	0.96	0.96	0.20	0.17	0.17	0.18	0.17	0.17
Mokelumne	Fall	Mokulemne River	1,500,000	3,500,000	0.96	0.96	0.96	0.96	0.96	0.96	0.20	0.17	0.17	0.18	0.17	0.17
Mokelumne Enhancement	Fall	Mokulemne River	0	2,000,000												
Merced	Fall	Merced River	300,000	0	0.96	0.96	0.96	0.96	0.96	0.96	0.20	0.17	0.17	0.18	0.17	0.17
Total	-	-	20,480,000	14,020,000	-	-	-	-	-	-	-	-	-	-	-	-

Total Freshwater Hatchery Survival (In-river and Bay releases)					
EXP1	EXP3	NAA	Alt2v1_	Alt2v2	Alt2v3
264,000	189,720	195,840	209,520	195,840	195,840
23,100	19,530	16,320	32,010	31,680	31,680
4,400	3,162	3,264	3,492	3,264	3,264
4,544,880	4,494,372	4,494,066	4,511,364	4,494,066	4,494,066
1,191,600	1,163,540	1,163,370	1,172,980	1,163,370	1,163,370
2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000
1,833,488	1,758,287	1,757,832	1,783,586	1,757,832	1,757,832
3,787,400	3,745,310	3,745,055	3,759,470	3,745,055	3,745,055
2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000
57,480	49,062	49,011	51,894	49,011	49,011
15,706,348	15,422,983	15,424,758	15,524,316	15,440,118	15,440,118

Hatchery and Natural Proportions and Ocean Abundance

Smolt to Adult Survival

Because release and recovery data are available and more reliable for the hatchery component of the Chinook salmon runs due to coded wire tags, the smolt to adult survival rate was estimated for the hatchery component and applied to the whole population (hatchery and natural) of smolts in the Bay. First it was necessary to estimate ocean abundance of all the CV Chinook salmon runs and then apply a hatchery proportion. This was important because the ocean abundance estimates for our largest CV Chinook salmon run (i.e., Sacramento River fall-run Chinook salmon) is estimated for the combined natural and hatchery origin fish.

The hatchery and natural area escapement proportions of CV Chinook salmon were estimated using data from the CV coded wire tag recovery reports for run years 2011–2022 (Palmer-Zwahlen and Kormos 2015; Palmer-Zwahlen et al. 2018, 2019, 2020; Letvin et al. 2021a, 2021b; Dean and Lindley 2023). The hatchery proportion over the 11 years of available data averaged 0.74 (range 0.57 to 0.88). A separate analysis of Chinook salmon otoliths in 1999 and 2002 found that the contribution of hatchery-produced fish made up approximately 90 percent of the ocean fishery off the central California coast from Bodega Bay to Monterey Bay (Barnett-Johnson et al. 2007); however, the more recent CV coded-wire-tag value of 0.74 overall CV hatchery proportion was used for this analysis.

The ocean abundance, hatchery releases, and hatchery proportions are values regularly estimated with greater confidence than the abundance of naturally produced Chinook salmon entering the ocean from the CV. Therefore, the median ocean abundance for the period 2001–2022 of 394,914 (Table 14) along with the hatchery proportion of 0.74 and median number of hatchery-produced fish in the Bay in the NAA scenario (15,424,758 from Table 13) was used to estimate the smolt in the bay-to adult survival rate of 0.0189[1]. Mortality sources other than that quantified in the fisheries (e.g., predation on adults by marine mammals) are not included in this estimate. Back calculating using the median ocean abundance, smolt to adult survival, and 0.74 hatchery proportion gives a NAA value for estimated number of naturally produced juvenile Chinook salmon in the Bay of 5,419,509 juveniles.

Ocean Abundance and Biomass of Adult (Age 3+) Chinook Salmon

The Sacramento River Index was used as the annual production of fall-run Chinook salmon from the CV. This index is the sum of the annual (September 1 to August 31) Sacramento River fall-run Chinook salmon ocean harvest South of Cape Falcon (~Columbia River mouth), fall-run Chinook salmon impacts from non-retention (released fish), recreational harvest of Sacramento River fall-run Chinook salmon in the Sacramento River basin, and the Sacramento River fall-run Chinook salmon spawner escapement (Pacific Fishery Management Council [PFMC] 2024). The ocean abundance of late fall-run, San Joaquin fall-run Chinook salmon, SR winter-run Chinook salmon, and CV spring-run Chinook salmon was estimated from annual escapement estimates as presented in PFMC (2024) plus an estimated ocean harvest. Each year's ocean harvest rate for

[1] (394,914 adult Chinook in the ocean *0.74 hatchery proportion)/ 15,424,758 hatchery fish in the bay = 0.0189 bay smolt to ocean adult survival (not including enumerated jacks)

late fall-run and CV spring-run Chinook salmon was assumed to be the same as the year's rate for fall-run Chinook salmon. Sacramento River winter-run Chinook salmon abundance assumed an annual harvest rate of 8.5 percent based on harvest management goals. Jacks, as enumerated in PFMC (2024), were excluded from the ocean abundance estimate for all runs because they were assumed to be too small to contribute significantly to SRKW prey.

The average size of adult Chinook salmon in the ocean varies from year-to year and is likely a function of the prey availability and current age distribution. The seasonal average dressed weight at the time of harvest in the commercial troll fishery ranged from 9.6 to 15.1 pounds from 2001 through 2022 (PFMC 2023). The dressed weight (assumed to be gutted, head off) was converted to live weight using a 1.33 conversion factor (NMFS 1980) resulting in live weight range of 14.4 to 20.1 pounds. Abundance and biomass have varied substantially from year to year with cohort replacement rates for all runs combined ranging from 0.28 to 3.58 (Figure 12 and Table 14).

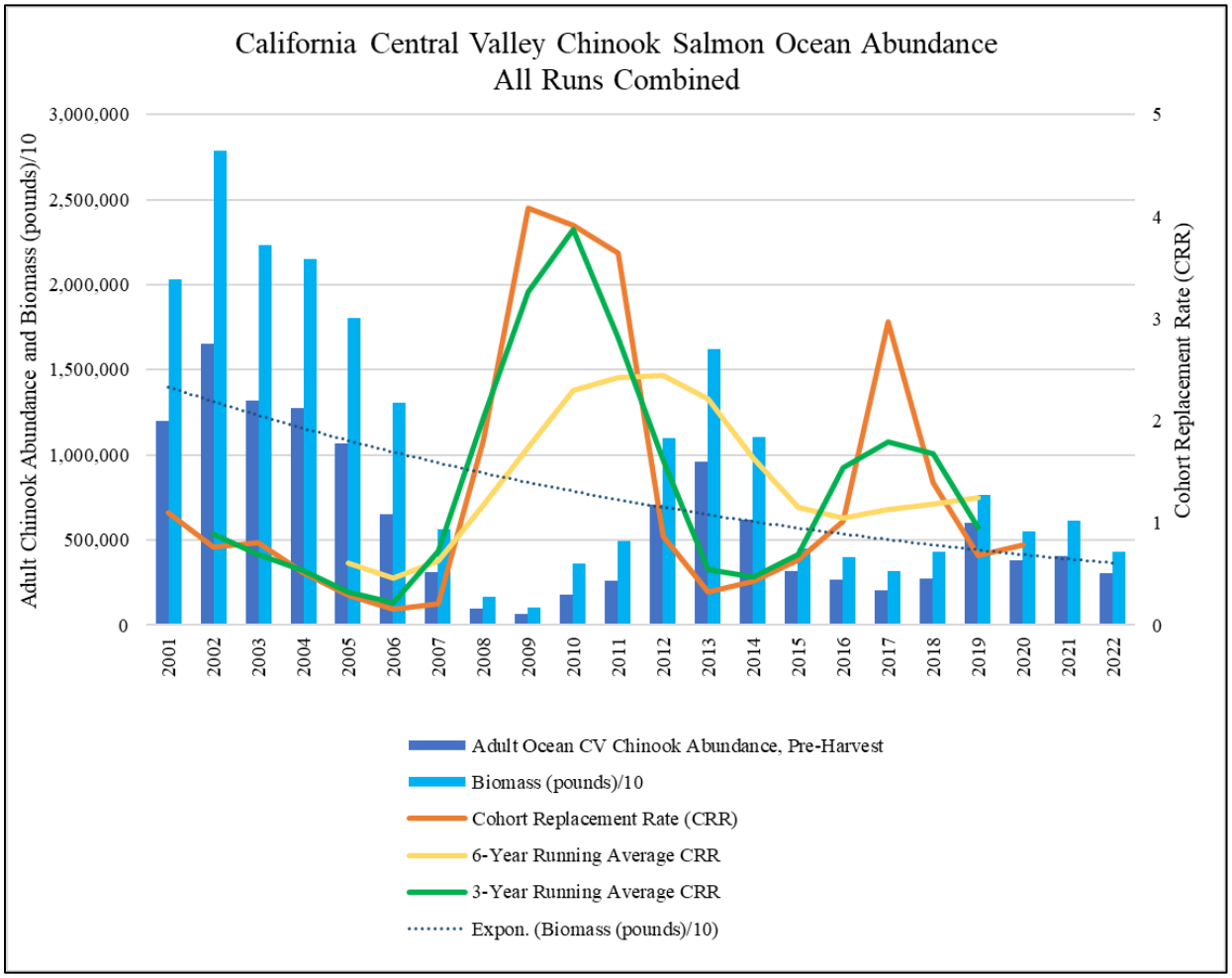


Figure 12. Ocean abundance, biomass, and cohort replacement rates for Central Valley Chinook salmon, all runs combined. Abundance is pre-harvest in the ocean fisheries and jacks are excluded.

Source: abundance calculated from data in Pacific Fishery Management Council (2024).

Table 14. Annual Central Valley Chinook salmon ocean abundance, all rivers and runs combined pre-harvest and estimated biomass of Chinook salmon from the Central Valley Jacks are excluded. Ocean abundance is calculated from data in Pacific Fishery Management Council (2024).

	Fall	**Late fall**	**Spring**	**winter**	**Adult Ocean Central Valley Chinook, pre-harvest**	**CRR (Cohort Replacement Rate**			**Dressed weight statewide season**	**live weight***	**Total biomass (pounds)**
2001	1,122,059	31,411	38,395	8,923	1,200,788	CRR			12.7	16.9	20,282,507
2002	1,546,698	59,801	37,064	8,073	1,651,636		6-yea r running average		12.7	16.9	16,818,979
2003	1,250,163	13,945	48,194	8,917	1,321,218	1.10		3-year running average	12.7	16.9	22,316,700
2004	1,209,274	24,763	30,013	8,538	1,272,587	0.77			12.7	16.9	21,495,269
2005	988,567	25,888	36,718	17,185	1,068,359	0.81		0.89	12.7	16.9	18,045,648
2006	593,507	22,935	19,617	18,766	654,825	0.51		0.70	15	20.0	13,063,766
2007	262,368	31,091	18,388	2,757	314,603	0.29		0.54	13.4	17.8	5,606,862
2008	71,874	10,994	14,190	3,071	100,129	0.15	0.61	0.32	12.8	16.5	1,652,125
2009	44,792	10,298	4,490	4,923	64,503	0.21	0.46	0.22	12.8	16.5	1,064,293
2010	161,919	11,686	5,411	1,732	180,748	1.81	0.63	0.72	15.1	20.1	3,629,957
2011	239,266	11,996	11,042	897	263,201	4.08	1.18	2.03	14.2	18.9	4,970,822
2012	660,491	9,278	34,760	2,898	707,428	3.91	1.74	3.27	11.7	15.6	11,008,283
2013	901,549	13,776	36,429	6,603	958,358	3.64	2.30	3.88	12.7	16.9	16,187,619
2014	579,724	21,011	15,953	3,271	619,960	0.88	2.42	2.81	13.4	17.8	11,048,921
2015	289,367	14,586	7,742	3,732	315,427	0.33	2.44	1.62	10.8	14.4	4,530,792
2016	246,479	8,756	12,687	1,681	269,604	0.43	2.21	0.55	11.2	14.9	4,016,020
2017	190,160	8,138	2,673	1,062	202,033	0.64	1.64	0.47	11.8	15.7	3,170,714
2018	256,248	7,884	7,535	2,863	274,530	1.02	1.16	0.70	11.9	15.8	4,344,984
2019	538,918	19,191	33,998	8,819	600,925	2.97	1.05	1.54	9.6	12.8	7,672,613
2020	361,329	8,292	5,303	8,059	382,983	1.40	1.13	1.80	10.8	14.4	5,501,174
2021	341,449	6,512	47,440	11,445	406,845	0.68	1.19	1.68	11.4	15.2	6,168,582
2022	270,980	12,697	12,151	6,583	302,411	0.79	1.25	0.95	10.8	14.4	4,343,827
Average	**551,236**	**17,497**	**21,827**	**6,400**	**596,959**				**12.40**	**16.45**	**9,909,967**
Median	**351,389**	**13,236**	**17,171**	**5,753**	**394,914**				**12.70**	**16.70**	**5,887,722**
Standard Deviation	**432,217**	**12,114**	**14,946**	**4,853**	**454,430**				**1**	**2**	**7,793,825**
	*2001 - 2005 was an average, 2008 and 2009 when no fishery occurred used 2001–2022 average.										
	Assumes same harvest rate for San Joaquin fall, late-fall, and Central Valley spring-run Chinook salmon and 8.5% harvest for Sacramento River winter-run Chinook salmon.										
	Note: the analysis uses the average 2011–2022 weight of 15.015 pounds.										

C-2. Abundance of Central Valley Chinook Salmon Available as Prey for Southern Resident Killer Whales

The estimated natural and hatchery juvenile Chinook salmon abundance in the Bay from Table 13 were combined for a total juvenile Chinook salmon in the Bay estimate under each operating scenario. A static Bay smolt-to-adult survival rate of 0.0189 was applied to all scenarios to arrive at an estimate of age 3+ adults present in the ocean and available to SRKW (Table 15). The adult abundance under the EXP3 of 395,378 comes from the estimated juvenile abundance in the Bay in the EXP3 multiplied by the smolt to adult survival of 0.0189. Median ocean adult abundance under the proposed action phases ranged from 393,427 in Alt2v2 to 395,355 in Alt2v1 among the Alternative 2 phases, and a median abundance range of 1,928 adult Chinook salmon among the proposed action phases. The 2.5th percentile and 97.5th percentile outputs of the model runs were used to estimate the upper and lower bounds of the 95% confidence interval (CI) of freshwater survival under each operating scenario. The static Bay smolt to adult survival rate of 0.189 was applied to these values across all scenarios as well to arrive at an estimate of age 3+ adults present in the ocean and available to SRKWs at the high and low end of the 95% CI (Table 15).

Figure 12 and Table 14 demonstrate the strong interannual variation in CV Chinook salmon abundance available to SRKWs as prey. The hatchery proportion of 0.74, potentially a low estimate, and the higher contribution of hatchery Bay releases in comparison with instream releases and naturally-produced Chinook salmon suggests that naturally-produced Chinook salmon from the CV, in aggregate, are in a depressed state in all scenarios. Hatchery-produced Chinook salmon likely supply the bulk of the Chinook salmon available to SRKWs from the CV. Given the hatchery release scenarios (i.e., Bay releases and high fish numbers) that seem to be needed to support desired harvests of Chinook salmon in the fisheries, unquantified behavioral and genetic effects to naturally produced Chinook salmon (e.g., age at return, stray rates, and hatchery/wild fish spawning together; Davison and Satterthwaite 2017) may continue to exacerbate the depressed state of naturally produced Chinook salmon with potential consequent effects on distribution and abundance of SRKW prey in the ocean. The difference in quality of the Chinook salmon, nutrition wise, by the time they reach a size usable by SRKWs is likely negligible between hatchery and naturally produced Chinook salmon.

Table 15. Abundance of Central Valley Chinook salmon available as prey for Southern Resident killer whales under the long-term operations scenarios.

Run	EXP3	NAA	Alt2v1	Alt2v2	Alt2v3	EXP1
Fall and Late Fall	5,339,827	5,315,072	5,238,796	5,221,040	5,222,052	5,401,270
Fall and Late Fall Hatchery Trucked	13,020,000	13,020,000	13,020,000	13,020,000	13,020,000	13,020,000
Fall and Late Fall Hatchery Released	1,236,281	1,238,124	1,327,844	1,253,484	1,253,484	1,490,348
Sacramento River Winter	31,821	31,397	31,297	31,425	31,764	76
Winter Hatchery Released	3,162	3,264	3,492	3,264	3,264	4,400
Central Valley Spring	74,138	73,040	73,139	73,199	73,487	76,490
Spring Hatchery Trucked	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000
Spring Hatchery Released	163,540	163,370	172,980	163,370	163,370	191,600
Total Freshwater Survival	***20,868,769***	***20,948,704***	***20,867,548***	***20,765,781***	***20,767,421***	***21,184,184***
2.5th Percentile Freshwater Survival	19,614,907	20,334,100	19,988,510	20,087,487	20,083,532	19,918,711
95.7th Percentile Freshwater Survival	22,714,474	22,058,975	21,756,894	21,749,757	21,790,170	22,516,099
Bay to Ocean Adult Survival	***0.189***	***0.189***	***0.189***	***0.189***	***0.189***	***0.189***
Median Ocean Adult Chinook Abundance	**395,378**	**394,914**	**395,355**	**393,427**	**393,458**	**401,354**
2.5th Percentile Ocean Adult Chinook Abundance	371,623	385,249	378,701	380,576	380,501	377,379
95.7th Percentile Ocean Adult Chinook Abundance	430,347	417,928	412,205	412,070	412,835	426,589
Median Ocean Adult Chinook Biomass*	**5,936,601**	**5,929,634**	**5,936,255**	**5,907,306**	**5,907,772**	**6,026,330**

*Based on median adult weight of 15.015 pounds

C-3. References

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