NATIONAL MARINE FISHERIES SERVICE
ENDANGERED SPECIES ACT SECTION 7
BIOLOGICAL OPINION

Title:	Biological Opinion on Long-term Operation of the Central Valley Project and the State Water Project
Consultation Conducted By:	West Coast Region, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce
Action Agency:	U.S. Bureau of Reclamation
Publisher:	National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce

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1 INTRODUCTION

The Endangered Species Act of 1973, as amended (ESA; 16 USC §1531 et seq.) establishes a national program for conserving threatened and endangered species of fish, wildlife, plants, and the habitats they depend on. Section 7(a)(2) of the ESA requires Federal agencies to insure that their actions are not likely to jeopardize the continued existence of endangered or threatened species or adversely modify or destroy their designated critical habitat. Federal agencies must do so in consultation with the National Marine Fisheries Service (NMFS) for threatened or endangered species (ESA-listed), or designated critical habitat that may be affected by the action that are under NMFS jurisdiction (50 CFR 402.14). If a Federal action agency determines that an action "may affect, but is not likely to adversely affect" endangered species, threatened species, or designated critical habitat and NMFS concurs with that determination for species under NMFS jurisdiction, consultation concludes informally (50 CFR 402.14). The Federal action agency shall confer with NMFS for species under NMFS jurisdiction on any action which is likely to jeopardize the continued existence of any species proposed to be listed or result in the destruction or adverse modification of proposed critical habitat (50 CFR 402.10).

Section 7(b)(3) of the ESA requires that at the conclusion of consultation, NMFS provides an opinion stating whether the Federal agency's action is likely to jeopardize ESA-listed species or destroy or adversely modify designated critical habitat. 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. If incidental take is expected, section 7(b)(4) requires NMFS to provide an incidental take statement that specifies the impact of any incidental taking and includes reasonable and prudent measures to minimize such impacts and terms and conditions to implement the reasonable and prudent measures.

This consultation, biological opinion (Opinion), and incidental take statement, were completed by NMFS in accordance with section 7(a)(2) and 7(b) of the statute (16 USC 1536), associated implementing regulations (50 CFR 402), and agency policy and guidance. Updates to the regulations governing interagency consultation (50 CFR 402) will become effective on October 28, 2019 (84 FR 44976). Because this consultation was pending and will be completed prior to that time, we are applying the previous regulations to the consultation. However, as the preamble to the final rule adopting the new regulations noted, "[t]his final rule does not lower or raise the bar on section 7 consultations, and it does not alter what is required or analyzed during a consultation. Instead, it improves clarity and consistency, streamlines consultations, and codifies existing practice." Thus, the updated regulations would not be expected to alter our analysis.

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 (section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001, Public Law 106-554).

This document represents NMFS' Opinion on the effects of the above actions on Sacramento River Winter-Run Chinook Salmon (*Oncorhynchus tshawytscha*), Central Valley Spring-Run Chinook Salmon (*Oncorhynchus tshawytscha*), California Central Valley Steelhead

(*Oncorhynchus mykiss*), Southern distinct population segment (DPS) of North American Green Sturgeon (*Acipenser medirostris*), and Southern Resident DPS of Killer Whale (*Orcinus orca*).

The action agency for this consultation is the United States (U.S.) Department of Interior, Bureau of Reclamation (Reclamation), and the California Department of Water Resources (DWR) is considered an applicant. On August 2, 2016, Reclamation requested reinitiation of ESA section 7 consultation with the U.S. Fish and Wildlife Service (FWS) and NMFS on the coordinated Long-Term Operation (LTO) of the Central Valley Project (CVP) and State Water Project (SWP). Several factors resulted in Reclamation requesting reinitiation of consultation under the ESA, including new information on the status of listed species, new information related to recent multiple years of drought, and the evolution of best available science. The proposed action for this reinitiation of consultation (ROC) is the coordinated LTO of the CVP and SWP.

1.1 Project Description

The CVP consists of 20 dams and reservoirs (see Figure 1) that together can store nearly 12 million acre-feet of water. Reclamation holds over 270 contracts and agreements for water supplies that depend upon CVP operations. Through operation of the CVP, Reclamation delivers water in 29 of California's 58 counties in the following approximate amounts: 5 million acre-feet of water for farms; 600 thousand acre-feet of water for municipal and industrial uses (enough water to supply about 2.5 million people for a year); and 355 thousand acre-feet of water for wildlife refuges. Reclamation operates the CVP under water rights granted by the State of California, including those intended to protect agricultural and fish and wildlife beneficial uses in the Sacramento–San Joaquin Delta (Delta). The CVP generates approximately 4.5 million megawatt hours of electricity annually on average.

The CVP was developed in segments, termed "Divisions." Reclamation described its action based on Divisions of the CVP as such, much of the consultation relied upon the Division construct. Hence, this Opinion is organized by Reclamation Divisions in the Effects of the Action section.

The SWP's main facilities are Oroville Dam, the Harvey O Banks Pumping Plant (Banks Pumping Plant), and San Luis Reservoir. These facilities are operated and connected by a network of canals, aqueducts, and other facilities of the SWP to deliver on average approximately 2.6 million acre-feet of contracted water supplies annually. DWR holds contracts with 29 public agencies in the Feather River Area, North Bay Area, South Bay Area, San Joaquin Valley, Central Coast, and Southern California for water supplies from the SWP.

Water stored in the Lake Oroville facilities, along with excess water available in the Delta, is captured in the Delta and conveyed through several facilities to SWP contractors. Through the SWP, DWR provides flood control below Oroville Dam and water for agricultural, municipal and industrial, recreational, and environmental purposes. DWR conserves water in Lake Oroville and makes releases to meet regulatory obligations and agreements tied to the operations of the SWP. Releases also serve three contractors in the Feather River area and two contractors from the North Bay Aqueduct. DWR pumps water at the Banks Pumping Plant in the Delta for delivery to the remaining 24 public water agencies in the SWP service areas south of the Delta.

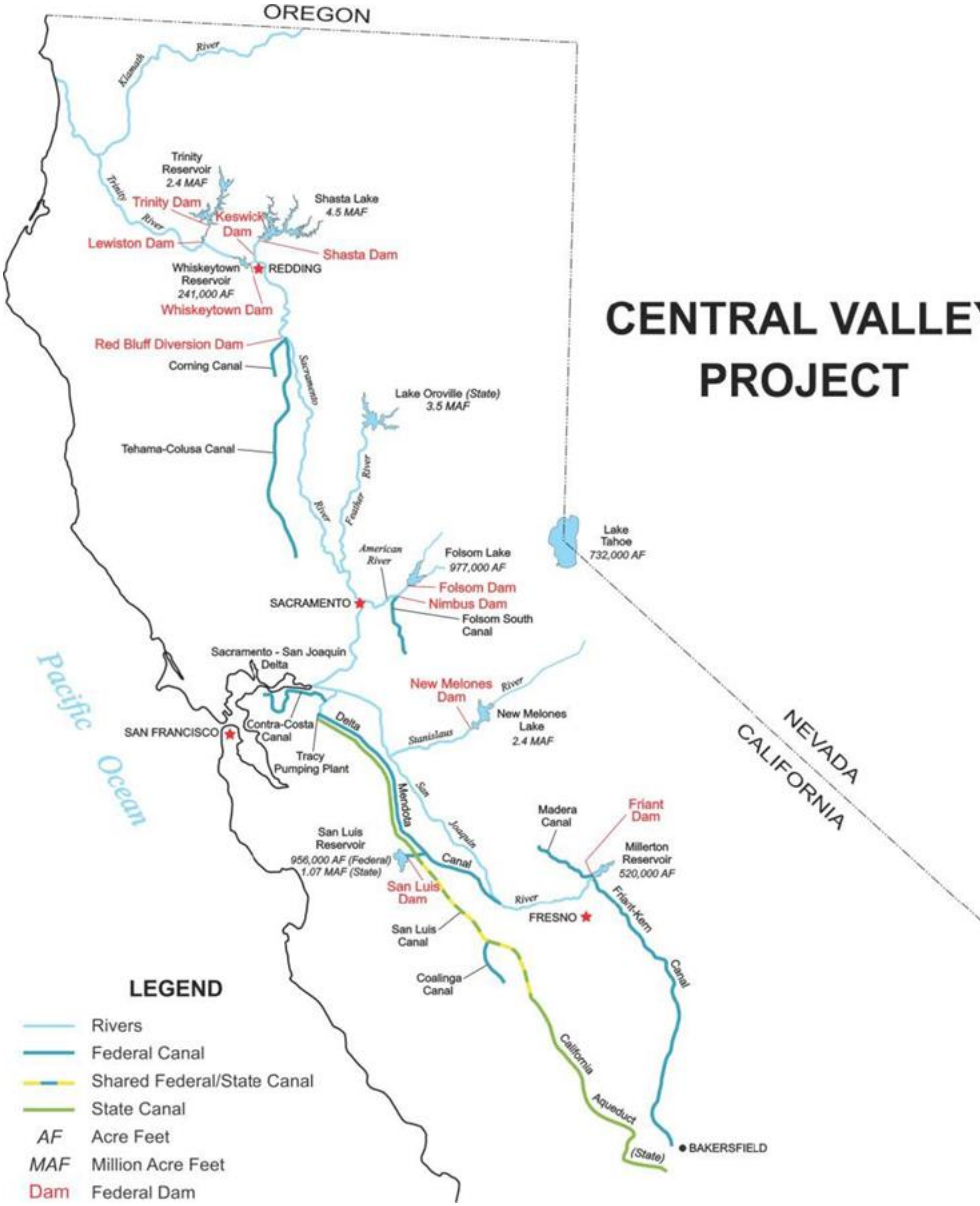


Figure 1. Map of California Central Valley Project dams and facilities.

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 water supply needed to meet Sacramento Valley in-basin uses and CVP/SWP exports. The *Coordinated Operations Agreement* is the Federal nexus for ESA section 7 consultation on operations of the SWP. In this Reinitiation of Consultation on Long-Term Operations (ROC on LTO), DWR is considered an applicant.

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 the ROC on LTO Biological Assessment (biological assessment)[1] (U.S. Bureau of Reclamation 2019c). 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. Every five years the parties shall (1) compare the relative success which each party has had in meeting its objectives, (2) review operation studies supporting this agreement, including, but not limited to, the assumptions contained therein, and (3) assess the influence of the factors and procedures of the in-basin uses in meeting each party's future objectives.

1.3 Key Consultation Considerations

Key considerations that provide context for this consultation include programs that were outside the scope of this consulation, such as CVP operations in the Trinity River and operation of Oroville Dam. Reclamation identified components of its action that have previously undergone ESA consultation that were therefore not included in the request for reinitiation of consultation. The non-essential Central Valley Spring-run Chinook salmon population in the Joaquin River

[1] Reclamation submitted an initial draft biological assessment to NMFS in January 2019 (U.S. Bureau of Reclamation 2019c). That document was updated several times during consultation. References in this Opinion are often to the January 2019 draft. Final conclusions and any supplemental analysis are based on the final biological assessment received in October 2019 (U.S. Bureau of Reclamation 2019d).

restoration program also falls outside of this consultation. The Water Infrastructure Improvement for the Nation (WIIN) Act was a key consideration during consultation. Below we summarize these items as context for this consultation.

1.3.1 Trinity River Division

Although the Trinity River Division is part of the Central Valley Project, actions in the Trinity River portion of the Trinity River Division were identified as having previously undergone ESA consultation with NMFS. Components of the Trinity River Division that affect the Klamath River basin were addressed in a separate consultation completed on January 1, 2019 (National Marine Fisheries Service 2019a), and were therefore excluded from this consultation. The remaining proposed action components of the Trinity River Division included in this Opinion are associated with transbasin diversions into Whiskeytown Reservoir. As a result, NMFS did not analyze any aspects of CVP operation on the Trinity and Klamath rivers, or their associated listed species (i.e., Pacific eulachon, Southern Oregon/Northern California Coast coho salmon) and designated critical habitats, as part of the proposed action. Neither was production of currently-unlisted Upper Klamath-Trinity River Chinook salmon evaluated as it pertains to Chinook salmon availability as prey for Southern resident killer whales (SRKW).

1.3.2 Linkage to the Operation of Oroville Dam

The Oroville Complex (Oroville Dam and related facilities, including the Feather River Fish Hatchery) 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 section 7 consultation and issued a biological opinion to FERC regarding the effects of relicensing the Oroville Complex for 50 years. Because the effects of operation of the Oroville Complex were considered in the consultation with FERC, that consultation is incorporated here by reference to satisfy the ESA section 7(a)(2) responsibility as a component of ongoing operations of the CVP.

1.3.3 Water Supply Contracts

Reclamation proposes to operate the CVP (and DWR for the SWP) to store, release, 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 and consistent with water rights and applicable law and regulations, which includes maximum water deliveries and diversions under the terms of existing contracts and agreements, including timing and allocation.

The contracts include water service and water repayment contracts, as well as settlement, exchange, and refuge contracts. In addition, it includes water delivery through temporary, not to exceed 1 year, “Section 215 Contracts,” when there are surplus flood flows, and the conveyance of non-CVP (which includes SWP) water when there is excess capacity available in CVP facilities (pursuant to the Warren Act). Finally, Reclamation proposes to operate the CVP to meet its obligations to deliver water to senior water right holders who received water prior to construction of the CVP, to wildlife refuge areas identified in the Central Valley Project Improvement Act (CVPIA), and to water service contractors.

The proposed action includes delivery of non-discretionary quantities of water to any contractor entitled to such non-discretionary deliveries, and NMFS' effects analyses for the delivery of non-discretionary quantities to any contractor is considered in the biological opinion and incidental take statement. Although Reclamation lacks 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)[2] Contractors, as well as other non-discretionary contractors, legal obligations and project purposes.

Specific to the SRS Contractors, Reclamation's proposed action includes a commitment to meet and confer with the SRS Contractors regarding potential modifications to operations during Tier 3 and Tier 4 years (see Section 3.1: *Upper Sacramento/Shasta Division Operations*). Reclamation, FWS, NMFS, DWR, CDFW, and the SRS Contractors will confer on measures to be considered if drought conditions continue into the following year, including measures that may be beyond Reclamation and DWR's discretion. If dry conditions continue, Reclamation will regularly meet with this group (and potentially other agencies and organizations) to evaluate current hydrologic conditions and the potential for continued dry conditions that may necessitate the need for development of a drought contingency plan (that may include actions from the toolkit of potential ways to address drought conditions that Reclamation has proposed to develop as part of its proposed action) for the water year. Collaboration among the parties in dry or critically dry years has been demonstrated in the past, such as when Reclamation requested, and the SRS Contractors voluntarily agreed, to reschedule diversions in 2014 and 2015. Reclamation used the water conserved by rescheduling diversions to help conserve storage to minimize drought related effects on Sacramento River winter-run Chinook salmon egg survival in response to drought conditions. Such collaborative actions are reasonably expected to occur under the proposed action, and may reduce the severity of effects of Tier 3 and Tier 4 years on Sacramento River winter-run Chinook salmon survival. Reclamation's commitment to exercising its discretion in this way was considered during consultation. This consultation also included water delivery through temporary, not to exceed one year, "Section 215 Contracts," when there are surplus flood flows, and the conveyance of non-CVP (which includes SWP) water when there is excess capacity available in CVP facilities (pursuant to the Warren Act). Reclamation is not proposing to execute any new contracts or amend any existing contracts as part of this consultation.

1.3.4 Peer Review of the Draft Biological Opinion

NMFS obtained two separate peer reviews of its draft Opinion. The first review was conducted on the June 2, 2019 draft Opinion through a contract with Anchor QEA. Three reviewers, Dr. Dave Hankin (Professor Emeritus, Humboldt State University), Dr. Kenneth Rose (Professor, University of Maryland Center for Environmental Science), and Dr. John Skalski (Professor, School of Aquatic and Fishery Sciences, University of Washington), were selected from a pool of 33 potential reviewers, based on availability, knowledge, and experience. Ultimately, however, Dr. Dave Hankin was not able to complete review due to scheduling constraints. The panel reviewed the analytical approach through effects sections of the draft opinion for all ESA-listed species and their critical habitats. The reviewers received relevant background information

[2] The Sacramento River Settlement Contractors, a California nonprofit mutual benefit corporation, consists of individuals and entities (collectively, SRS Contractors) that individually hold settlement agreements (the SRS Contracts) with the United States Bureau of Reclamation (Reclamation)

and supplemental materials to consider in their reviews. NMFS was available during the review period to respond to questions or address clarification needs during the reviews.

On June 14, 2019, the peer reviewers issued their individual reports and findings to Anchor QEA and NMFS. Each of the peer review reports had constructive recommendations towards 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 applied the best available information in its development of the draft Opinion.

The second peer review was conducted on the July 30, 2019 draft Opinion through a contract with Atkins North America, Inc. Three peer reviewers were selected: Hans Berge (Cramer Fish Sciences), Dr. Nancy Monsen (Independent Delta Hydrodynamics Consultant) and Dr. Kenneth Rose (University of Maryland Center for Environmental Science). Reviewers were provided the Introduction through Integration and Synthesis sections of the July 30, 2019 draft Opinion. Reviewers were also provided seven questions to focus their review. On August 13, 2019, NMFS received the peer reviewers' individual reports and findings. Similar to the first peer review, the reports had constructive recommendations and acknowledged that NMFS utilized the best available information to complete a comprehensive analysis of the proposed action.

This Opinion, and its supporting administrative record, considered and/or incorporated all of the substantive recommendations from both peer reviews, as appropriate.

1.3.5 Central Valley Spring-run Chinook Salmon in the San Joaquin River

In 2013, NMFS designated a non-essential experimental population of CV spring-run Chinook salmon for reintroduction to the San Joaquin River in accordance with section 10(j) of the ESA (78 FR 79622). This designation allows for the release of listed CV spring-run Chinook salmon outside their current range as an experimental population; given that, the non-essential population is geographically separate from the threatened population of the same species and if lost, will not significantly impact the status of that species. 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 10(j) rule has allowed the San Joaquin River Restoration Program to begin reintroduction efforts in the restoration area while still meeting the San Joaquin River Restoration Settlement Act's (Settlement Act) requirement of no more than *de minimus* water supply impacts to third parties.

This non-essential population was not considered 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 to the 10(j) population, phenotypically spring-running Chinook salmon have been observed in the Tuolumne and Stanislaus Rivers of the San Joaquin Basin in the last decade (Franks 2014). These fish may represent strays from the Feather River hatchery (fall- or spring-run) or spring-run Chinook salmon produced in the Sacramento Basin. We currently do not have enough information to determine whether these individuals are part of the listed CV spring-run Chinook salmon ESU. Therefore, NMFS does not further consider effects of the proposed action on these fish in the jeopardy analysis for this species.

1.3.6 Water Infrastructure Improvement 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." The Analytical Approach through Effects sections were shared with the public water agencies through Reclamation on June 3, 2019. The public water agencies provided written comments on the draft biological opinion on June 14, 2019, through Reclamation, which were afforded due consideration during the consultation. The updated draft Opinion was transmitted to peer reviewers as described above, State of California, and public water agencies on July 31 for a comment period through August 9. Comments were received and afforded further consideration during the consultation. In addition, an updated draft Opinion was shared with public water agencies through Reclamation during a meeting on October 7, 2019 and comments gathered during that discussion were further considered and addressed in this Opinion.

1.3.7 Sacramento River Settlement Contractors Resolution

During consultation, the SRS 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 (Sacramento River Settlement Contractors 2019). The SRS Contractors, a California nonprofit mutual benefit corporation, consists of individuals and entities that individually hold settlement agreements (the SRS Contracts) with Reclamation. The SRS Contractors 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 Central Valley Project and in accordance with the terms of the SRS Contracts.

The SRS Contractors resolution includes three key actions that are integrated into the proposed action in this Opinion:

1. The SRS Contractors will meet and confer with Reclamation, NMFS, and other appropriate agencies to determine if there is any role for the SRS Contractors in connection with Reclamation's operational decision-making for Shasta Reservoir annual operations during drier water years with operational conditions as described in the Tier 3 and Tier 4 scenarios. 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 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.
3. The SRS Contractors will continue their active engagement and leadership in the ongoing collaborative Sacramento River Science Partnership effort.

1.4 Consultation History

Reclamation has consulted with NMFS on CVP operations as species were listed and critical habitat designated since the early 1990s (Table 1). The most recent consultation on CVP operations was completed on June 4, 2009 (National Marine Fisheries Service 2009b). The 2009 opinion was challenged in federal court. On appeal, the 2009 opinion was upheld and Reclamation issued a Record of Decision to adopt it in 2016.

Table 1. Consultation history for the reinitiation of consultation on the long-term operations of the Central Valley Project and State Water Project.

Date	Issuer	Document	Rationale for Consultation	Subject/ Species	Finding
February 1992	Reclamation	Interim Central Valley Project Operations Criteria and Plan	Newly listed Winter-Run Chinook salmon (listed in 1991)	Short term to address drought operations and Winter-Run Chinook Salmon	Jeopardy
June 1993	NMFS	Biological Opinion	Winter-Run listed in 1991	Winter-Run Chinook Salmon	Jeopardy
June 2004	Reclamation	Biological Assessment	Combined ESA species consultation in one assessment	Winter-Run Chinook Salmon, Spring-Run Chinook Salmon, Steelhead, Coho Salmon, Delta Smelt	Likely to Adversely Affect: Winter-run, Spring-run, CV Steelhead; May Affect/Not Likely to Adversely Affect: Coho, Delta Smelt
October 2004	NMFS	Biological Opinion	Combined ESA species consultation	Winter-Run Chinook Salmon, Spring-Run Chinook Salmon, Steelhead, Coho Salmon	Non-Jeopardy
May 2008	Reclamation	Biological Assessment	Green Sturgeon was listed in 2006; Pelagic Organism Decline	Winter-Run Chinook Salmon, Spring-Run Chinook Salmon, Steelhead, Green Sturgeon, Coho Salmon, Delta Smelt	Adversely Affect: Delta Smelt; Likely to Adversely Affect: CV steelhead, Winter-run, Spring-run; Green Sturgeon; Not Likely to Adversely Affect: Coho Salmon
June 2009	NMFS	Biological Opinion and Conference Opinion	Green Sturgeon listed in 2006	Winter-Run Chinook Salmon, Spring-Run Chinook Salmon, Steelhead, Green Sturgeon*	Jeopardy and Adverse Modification of Critical Habitat
January 2019	Reclamation	Biological Assessment	Drought; New Science	Winter-Run Chinook Salmon, Spring-Run Chinook Salmon, Steelhead, Green Sturgeon, Coho, Delta Smelt*	See Effects Determination in the biological assessment

**Southern Resident killer whales were also part of the consultations, but their critical habitat is not in the action area.* *Source:adapted from (U.S. Bureau of Reclamation 2019c)*

On August 2, 2016, Reclamation requested ESA section 7 reinitiation of consultation on the CVP/SWP, based on new information related to multiple years of drought, recent data demonstrating extremely low population levels for the endangered Sacramento River winter-run Chinook salmon, and new information available and expected to become available as a result of ongoing work through collaborative science processes. On August 17, 2016, NMFS responded, indicating that this type of operations consultation is most efficiently done with participation of multiple agencies, including Reclamation, DWR, California Department of Fish and Wildlife (CDFW), and FWS, along with NMFS (collectively "five agencies").

From February 2017 through June 2018, Reclamation convened a five agencies ROC on LTO Core Team to work through various issues associated with the consultation. The five agencies Core Team also developed background and process materials in preparation for brainstorming meetings.

From June 2017 through January 2018, Reclamation led five-agency (plus watershed tribes and Western Area Power Administration representatives) brainstorming workshops within each CVP-controlled stream geographic area to help Reclamation develop National Environmental Policy Act alternatives for the reinitiation.

On October 19, 2018, the White House issued a memorandum titled, "Promoting the Reliable Supply and Delivery of Water in the West." The key excerpts pertaining to the CVP/SWP operations consultation include:

> *"Section 2(c)(ii): The Secretary of the Interior shall issue final biological assessments for the long-term coordinated operations of the Central Valley Project and the California State Water Project not later than January 31, 2019.*
>
> *Section 2(c)(iii): The Secretary of the Interior and the Secretary of Commerce shall ensure the issuance of their respective final biological opinions for the long-term coordinated operations of the Central Valley Project and the California State Water Project within 135 days of the deadline provided in section 2(c)(ii) of this memorandum. To the extent practicable and consistent with law, these shall be joint opinions.*
>
> *Section 2(d): The Secretary of the Interior and the Secretary of Commerce shall provide monthly updates to the Chair of the Council on Environmental Quality and other components of the Executive Office of the President, as appropriate, regarding progress in meeting the established timelines."*

Throughout November and December, 2018, NMFS provided Reclamation with technical assistance towards their development of a biological assessment for the ROC on LTO.

NMFS was affected by the partial Federal government shutdown from December 22, 2018, through January 25, 2019, precluding any further technical assistance from NMFS staff, including the opportunity to review much of the draft biological assessment effects analyses prior to finalization on January 31, 2019.

1.4.1 January 2019 Biological Assessment and Proposed Action

On January 31, 2019, Reclamation submitted a letter, transmitting an enclosed biological assessment to NMFS, requesting the ROC on LTO and its effects on:

- Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*) and their designated critical habitat,
- Central Valley spring-run Chinook salmon (*O. tshawytscha*) and their designated critical habitat,
- California Central Valley (CCV) steelhead (*O. mykiss*) and their designated critical habitat,
- Southern Distinct Population Segment (sDPS) of North American green sturgeon (*Acipenser medirostris*) and their designated critical habitat,
- Southern Oregon/Northern California Coast coho salmon (*O. kisutch*) and their designated critical habitat,
- Southern DPS of eulachon (*Thaleichthys pacificus*) and their designated critical habitat, and,
- Southern Resident killer whales (SRKW) (*Orcinus orca*).

Reclamation made "no effect" determinations on Central California Coast steelhead (*O. mykiss*) and their designated critical habitat.

In addition, Reclamation made the following effect determinations for essential fish habitat pursuant to the Magnuson-Stevens Fishery Conservation and Management Act of 1976:

- Would adversely affect:
    - Pacific Coast Salmon
    - Pacific Coast Groundfish
- Not likely to adversely affect:
    - Coastal Pelagic Species

Therefore, Reclamation also requested essential fish habitat consultation. During consultation, and largely based on the iterative nature of the ESA consultation that resulted in numerous changes to the proposed action, NMFS decided to separate the ESA and essential fish habitat consultation analysis and conclusion documents. Therefore, the essential fish habitat consultation is occurring separately and on a different schedule.

On February 5, 2019, Reclamation provided the CVP/SWP operations biological assessment (U.S. Bureau of Reclamation 2019c).

From February 5 to February 21, 2019, NMFS completed its initial review of the biological assessment. On February 22, 2019, NMFS sent a list of the most important comments associated with the proposed action and effects of the action to the five agencies. On February 22, 2019, the five agencies convened to discuss the most important issues in the biological assessment associated with Shasta Reservoir and Delta operations, in particular. Follow-up meetings for the Trinity River, Clear Creek, Feather River, American River, the Delta, and the Stanislaus River were held the week of February 27, 2019. Follow-up meetings for storage management and allocations, and seasonal temperature management modeling, were held March 5 and March 12, 2019, respectively.

NMFS requested and Reclamation provided results for the following: (1) Additional DSM2-HYDRO analyses, (2) CalSimII model, (3) HEC-5Q temperature model, (4) RBM-10 temperature model, (5) Sacramento River egg mortality models (both Anderson and Martin), (6) Delta Passage Model, (7) IOS model, (8) Central Valley Project Improvement Act (CVPIA) Science Integration Team survival relationships, (9) Salvage-Density Method, (10) SALMOD, (11) Weighted usable area analyses, (12) Trinity Stream Salmonid Simulator model, and (13) Coho salmon habitat modeling. Reclamation submitted the last of the model results to NMFS on April 5, 2019.

1.4.2 April 19, 2019 Proposed Action

On April 1, 2019, Reclamation distributed via e-mail a revised proposed action that did not include track changes compared to the February 5, 2019, version. On April 30, 2019, Reclamation sent NMFS the proposed action from an April 19, 2019 revised proposed action, in track changes compared to the February 5, 2019, version of the proposed action (U.S. Bureau of Reclamation 2019a). Revisions include inclusion (or removal) of proposed action components, clarification of proposed action components (e.g., Section 4.10.1.4 Fall and Winter Refill and Redd Maintenance), and more complete description of proposed action components (e.g., Section 4.10.5.8 Clifton Court Aquatic Weed and Algal Bloom Management).

On May 16, 2019, Council on Environmental Quality granted NMFS a two-week extension to July 1, 2019, to issue a final biological opinion per Section 2(d) of the October 19, 2018, White House memorandum.

1.4.3 July 30, 2019 Revised Proposed Action

Following Reclamation's submittal of the April 19, 2019, proposed action, Reclamation worked with NMFS to provide additional information, including clarification of conflicting language in the proposed action and specific operational elements of the proposed action. Reclamation performed additional analysis of the proposed action, including runs of various biological models and a sensitivity analysis of Tier 3 temperature modeling. These clarifications and measures were incorporated into the July 30, 2019 revised proposed action.

1.4.4 Final October 11, 2019 Proposed Action

NMFS and Reclamation continued to meet to review and discuss the proposed action. During this process, Reclamation continued to clarify their proposed action, providing additional information about allocations and forecasts and cold water management, and committing to performance metrics for temperature management, independent scientific review of proposed action performance, ramping rates for flow management, and additional conservation measures. Reclamation further clarified their commitments to ongoing collaborative planning to identify and implement actions to benefit listed species, and committed to review proposed action performance at specified intervals and meet with State and Federal partners in defined circumstances to coordinate drought year planning. This resulted in a final proposed action as of October 17, 2019, which is analysed in this opinion. NMFS relied on these modifications and clarifications to the proposed action to substantially revise their original Opinion draft discussions of the anticipated effects of the action. The updated analyses modify the evaluation of the January 31, 2019, biological assessment as described in this document.

1.4.5 The 2009 Opinion Reasonable and Prudent Alternative

The 2009 opinion on Reclamation's 2008 biological assessment (U.S. Bureau of Reclamation 2008) resulted in the development of a RPA to the proposed action that would avoid jeopardizing listed species or adversely modifying their critical habitat. A summary of the most significant ways CVP and SWP water operations adversely affect listed species that were addressed in the 2009 RPA was included in the 2009 Opinion. Reclamation's 2019 proposed action includes changes that have similar objectives or goals as the 2009 RPA (Table 2).

Table 2. Comparision of concerns addressed by the 2009 Reasonable and Prudent Alternative (RPA) and Reclamation's 2019 proposed action for the Central Valley Project and State Water Project.

2009 RPA Addressed Concern	2019 Proposed Action
Shasta Dam water operations result in elevated water temperatures that have lethal and sublethal effects on egg incubation and juvenile rearing in the upper Sacramento River. Operational cause is lack of sufficient cold water in storage to allow for cold water releases to reduce downstream temperatures at critical times and meet other project demands. The RPA had a year-round storage and temperature management program for Shasta Reservoir and the Upper Sacramento River.	Proposed action includes actions to build Shasta Reservoir storage in the fall and winter months and manage to a sustainable plan throughout the summer months. Efforts to explicitly build storage primarily include fall and winter refill and redd maintenance actions. Other actions which are likely to result in higher storage from historical include a modification to sharing responsibility under the Central Valley Project/State Water Project Coordinated Operation Agreement, reduced fall outflow and salinity targets in wet years and increased flexibility on summer releases for exports resulting from increased spring exports. The Shasta Cold Water Pool Management Plan addresses temperature goals with commitments to operate to the lowest tier possible, to stay within a tier once selected on May 1st and to coordinate temperature plans through the Sacramento River Temperature Task Group. Tier 3 and Tier 4 actions include intervention measures to reduce risks in drier/lower storage years and will be developed through collaboration with NMFS and others. The proposed action also includes a commitment to biological performance metrics and independent review process to evaluate performance and highlight areas for improvement.
In Clear Creek, recent project operations have led to increased abundance of CV spring-run Chinook salmon, which is an essential population for the short-term and long-term survival of the species.The RPA ensures that essential flows and temperatures for holding, egg incubation and juvenile survival will be maintained.	Updated flow schedule for Clear Creek including pulse flows and channel mobilization flows with higher base flow of 200 cfs October 1 through May 31, 150 cfs from June to September in all except critical years.Commitment to temperature targets identified in the RPA and use of flow to meet targets in the late fall with acknowledgement that late summer/early fall temperatures can not always be met and will be coordinated through the relevant technical group. Commitment to pulse flows and gravel movement to meet the intent of previous RPA actions.

2009 RPA Addressed Concern	2019 Proposed Action
Red Bluff Diversion Dam on the Sacramento River impedes both upstream migration of adult fish to spawning habitat and downstream migration of juveniles. The RPA mandates gate openings at critical times in the short term while an alternative pumping plant is built, and by 2012, the opening of the gates all year.	Red Bluff Diversion Dam is no longer operational and gates remain open year-round.
Both project and non-project effects have led to a significant reduction in necessary juvenile rearing habitat in the Sacramento River Basin and Delta. The project's flood control operations result in adverse effects through reduced frequency and magnitude of inundation of rearing habitat. The RPA contains both short-term and long-term actions for improving juvenile rearing habitat in the Lower Sacramento River and northern Delta.	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. Old and Middle River Reverse flows based on species distribution, modeling, and risk analysis with provisions for capturing storm flows The proposed action includes implementation of the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project. Between 2017 and 2019, completion of the Wallace Weir Fish Collection Facility, Fremont Weir Adult Fish Passage Project, and Agricultural Crossings have alleviated adult salmon straying and delays. Signature of the Record of Decision in September 2019 and financing of the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project will provide necessary juvenile salmonid rearing habitat in the Lower Sacramento River and northern Delta as soon as 2021.
Another major effect of water operations is diversion of out-migrating juveniles from the north Delta tributaries into the interior Delta through the open Delta Cross Channel gates. The RPA mandates additional gate closures to minimize these adverse effects to winter-run, spring-run, and steelhead.	Delta Cross Channel gates operation based on real-time information to close gates to protect fish and operations to avoid exceeding D-1641 water quality standards. Delta Cross Channel gate operations consistent with NMFS RPA except allowing for temporary openings to avoid D-1641 water quality exceedances rather than waiting for an actual exceedance before opening. Proposed action includes a commitment to reduce pumping to minimum health and safety levels before opening for avoiding a water quality exceedance from December 1 to January 31

2009 RPA Addressed Concern	2019 Proposed Action
Water pumping causes reverse flows, leading to loss of juveniles migrating out from the Sacramento River system in the interior Delta and more juveniles being exposed to the State and Federal pumps, where they are salvaged at the facilities. The RPA prescribes Old and Middle River flow levels and pumping restriction in April and May based on water year type and flows at Vernalis to reduce the number of juveniles exposed to the export facilities and prescribes additional measures at the facilities themselves to increase survival of fish.	The proposed action makes a commitment to stay within the Delta pumping-related loss experienced under the 2009 RPA. Old and Middle River Reverse flows will be limited based on timing (no greater than -5,000 cfs Jan-Jun); water quality conditions (short term protections for first flush events); storm event flexibility (can increase beyond -5,000 cfs if there is not a risk to the species); observed annual salvage and loss (specific triggers for loss values similar to those seen under the 2009 RPA); cumulative loss and outcomes from independent review panels. Skinner Delta Fish Protective Facility Improvements: DWR would continue implementation of projects to reduce mortality of ESA-listed fish species. These measures that would be implemented include: (a) electro-shocking and relocating predators; (b) controlling aquatic weeds; (c) developing a fishing incentives or reward program for predators; and (d) operational changes when listed species are present.
Juvenile steelhead migrating out from the San Joaquin River Basin have a particularly high rate of loss due to both project and non-project related stressors. The RPA mandates additional measures to improve survival of San Joaquin steelhead smolts, including both increased San Joaquin River flows and export curtailments. Given the uncertainty of the relationship between flow and exports, the RPA also prescribes a significant new study of acoustic tagged fish in the San Joaquin Basin to evaluate the effectiveness of the RPA and refine it over the lifetime of the project.	San Joaquin River Restoration Program flows - See Old and Middle River action description above. Salvage and loss threshold for steelhead divided into two time periods to protect San Joaquin steelhead that have a different emigration timing from other CV basin steelhead. The proposed action includes actions reducing project and non-project related effects such as predator hot spots in the South Delta, Stanislaus River outmigration flows, and specific performance objectives for juvenile steelhead loss, which may be modified to reflect updated population status information after four years. The proposed action includes significant new science investigations to develop this population status information for both CVP and non-CVP tributaries in the San Joaquin basin.

2009 RPA Addressed Concern	2019 Proposed Action
On the American River, project-related effects on steelhead are pronounced due to the inability to consistently provide suitable temperatures for various life stages and flow-related effects caused by operations. The RPA prescribes a flow management standard, a temperature management plan, additional technological fixes to temperature control structures, and, in the long term, a passage at Nimbus and Folsom Dams to restore steelhead to native habitat.	The proposed action is consistent with the approach under the 2009 RPA with a modified flow management standard that targets preserving coldwater pool in the drier years to improve temperature management and reduce the magnitude and frequency of the high temperatures seen under the 2013-2016 drought. A commitment to modify the shutters in drought conditions is also included to improve temperature management.
On the Stanislaus River, project operations have led to significant degradation of floodplain and rearing habitat for steelhead. Low flows also distort cues associated with out-migration. The RPA proposes a year-round flow regime necessary to minimize project effects to each life-stage of steelhead, including new spring flows that will support rearing habitat formation and inundation, and will create pulses that cue out-migration.	The proposed action is similar to the approach under the 2009 RPA with a revised flow schedule (Stepped Release Plan) for above normal and wet water year types that decreases minimum flows to target higher storage levels for addressing temperature concerns. Higher storage levels also increase the frequency of flood control releases to address the need for high geomorphic flow releases. The proposed action also changes water year type definitions to focus solely on hydrology rather than hydrology plus storage levels.
Nimbus Fish Hatchery steelhead program contributes to both loss of genetic diversity and mixing of natural origin and hatchery stocks of steelhead, which reduces the viability of natural origin stocks. The Nimbus and Trinity River Hatchery programs for non-listed Fall-run Chinook also contribute to a loss of genetic diversity, and therefore, viability, for Fall-run. The RPA requires development of Hatchery Genetics Management Plans and genetic studies at Nimbus to improve genetic diversity of both steelhead and fall-run Chinook, an essential prey base of Southern Resident Killer Whale.	The proposed action is consistent with the 2009 RPA by including a commitment to complete a Hatchery and Genetic Management Plan and additional specificity on the goals of the HGMP.

The proposed action has similar objectives as the RPA but with some differences in the approach to meet the objectives and through the consultation process, NMFS sought and received clarifications or more information on aspects of the proposed action. For example, in regard to the management of the Shasta cold water pool, Reclamation quantified Shasta Reservoir storage levels and frequencies of the Upper Sacramento tiered temperature management strategy. Reclamation clarified that proposed action uses a conservative forecast in seasonal planning of reservoir releases (including developing initial and updated allocations) and temperature management planning such that monthly release forecasts and associated allocations are typically based on a 90 percent exceedance inflow forecast through September. First, Reclamation will operate to the most protective tier that is achievable. Second, Reclamation made a commitment that, once the temperature tier is selected, it will not shift to a warmer tier except in an emergency or other unforeseen circumstances. Specific to drought and dry year operations, Reclamation modified its Tier 3 proposed action component to apply commitments made in Tier 4 years to discuss intervention measures to address low storage conditions if the Tier 3 year is forecast to be at the lower end of Tier 3.

Reclamation added a commitment to coordinate with NMFS, FWS, CDFW and DWR in developing a toolkit of actions to address drought. Drought and dry year planning will include measures under Shasta Cold Water Pool Management dry years, drought years, and successive dry years.

Additional details regarding voluntary Shasta critical year actions, as well as a Shasta critical year discussion process and reporting were developed to add certainty in drought conditions. If egg-to-fry survival in the Upper Sacramento River is less than 15 percent in two successive years, Reclamation proposed a process for director discussions. Reclamation committed to metrics to ensure performance falls within the modeled range as a further commitment to improve confidence that Reclamation is meeting temperature management objectives to improve egg-to-fry survival.

Reclamation committed to review by an independent panel to ensure that performance occurs as expected. The panel will review and recommend alternative steps if the objectives are not being met.

For the proposed action’s spring pulse flows on the Upper Sacramento River, Reclamation quantified the volume and timing of these pulse flows. On Clear Creek, American River, and Stanislaus River, Reclamation added ramping rate protocols for flow reductions from CVP reservoirs.

In the Delta, Reclamation added to the proposed action the following measures to reduce losses at the export facilities: (1) cumulative loss thresholds in addition to single-year thresholds; (2) spring-run Chinook surrogate off-ramps for Old and Middle River storm flexibility; and (3) triggers and off-ramps for the Integrated Early Winter Pulse Protection action for Delta smelt.

Ramping rates for flow changes were added to clarify that Reclamation would continue to implement ramping rates to avoid stranding fish.

Reclamation clarified that it will implement actions through collaborative planning to continue to identify and implement actions that benefit listed species through the Collaborative Science Adaptive Management Program, Interagency Ecological Program, Delta Plan Interagency Implementation Committee and CVPIA planning groups.

Four-year and eight-year reviews: Reclamation also added a commitment to review the implementation of the proposed action at four year intervals through an independent panel of experts to review the Upper Sacramento River Performance Metrics; Old and Middle Rivers management and measures to improve survival through the south Delta and Delta Smelt Summer-Fall Habitat Actions.

In addition, during drier water years with operational conditions that match Tier 3 and Tier 4 scenarios (see Section 3.1), Reclamation will meet and confer with FWS, NMFS, DWR, CDFW, and SRS Contractors on voluntary measures to be considered if drought conditions continue into the following year, including measures that may be beyond Reclamation and DWR's discretion.

Reclamation, FWS, and NMFS worked together to identify additional commitments to significantly benefit the protected species:

- Deer Creek Irrigation District Dam Fish Passage: Reclamation will provide up to $1,000,000 towards a collaborative project to construct fish passage downstream of the Deer Creek Irrigation District Dam to provide spring-run Chinook salmon and Central Valley steelhead with unimpeded access to 25 miles of prime spawning habitat. Improving fish passage at this site will improve upstream access to spawning, rearing and holding habitat.
- Knights Landing Outfall Gates: Reclamation will provide up to $700,000 toward reconstruction of the Knights Landing Outfall Gates to reduce the potential for fish straying into and getting trapped in the Colusa Basin Drain.
- Battle Creek Reintroduction Plan: Reclamation commits to providing up to $14,500,000 over ten years to reintroduce of Winter-run Chinook salmon to Battle Creek. Reclamation will accelerate implementation of the Battle Creek Salmon and Steelhead Restoration Project, which is intended to reestablish approximately 42 miles of prime salmon and Steelhead habitat on Battle Creek, and an additional 6 miles on its tributaries. The intent is to expand Winter-Run Chinook Salmon spawning beyond its current limited range in a single spawning population in the upper Sacramento River through fish passage construction and reintroduction of winter run Chinook.

2 THE ASSESSMENT FRAMEWORK

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.

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.

This Opinion includes both a jeopardy analysis and an adverse modification analysis. The jeopardy analysis relies upon the regulatory definition of "to 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.

During consultation we relied on the regulatory definition of "destruction or adverse modification," which means "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 physical or biological features essential to the conservation of a species or that preclude or significantly delay development of such features" (50 CFR 402.02).

Additional requirements for the analysis of the effects of an action are described in regulations (50 CFR 402.02). The conclusions related to "jeopardize the continued existence of" and "destruction or adverse modification" require an evaluation of direct and indirect effects of the proposed action, interrelated and interdependent actions, 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)).

The designations of critical habitat for some of the listed fish included in this consultation use the term "primary constituent elements" or "essential features." The revised critical habitat regulations (81 FR 7414) replace this term with physical or biological features. 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 primary constituent elements, physical or biological features, or essential features.

The ESA and its implementing regulations require NMFS to use the best scientific and commercial data available to complete formal consultations. However, NMFS is "'not required to support its finding that a significant risk exists with anything approaching scientific certainty.'" *San Luis & Delta-Mendota Water Auth. v. Jewell*, 747 F.3d 581, 592 (9th Cir. 2014) (citations omitted). 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 takes into account the underlying purposes of section 7 of the ESA and employs the precautionary principle where appropriate.

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. For biological opinions, section 7 of the ESA, implementing regulations (50 CFR 402.14), and associated guidance documents result in biological opinions to present the following:

- A description of the action to be considered
- 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 it is reasonable to expect that the proposed action is not likely to appreciably reduce the species' likelihood of both surviving and recovering 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 subsections below outline the specific framework, key steps, assumptions, and professional judgment NMFS used to assess the effects of the action on listed species and critical habitat. 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 Sacramento River winter-run Chinook salmon evolutionarily significant unit (ESU) (*Oncorhynchus tshawytscha*) and its designated critical habitat
- Threatened Central Valley (CV) spring-run Chinook salmon ESU (*O. tshawytscha*) and its designated critical habitat
- Threatened California Central Valley (CCV) steelhead distinct population segment (DPS) (*O. mykiss*) and its designated critical habitat
- Threatened Southern DPS (sDPS) of North American green sturgeon (*Acipenser medirostris*) and its designated critical habitat
- Endangered Southern Resident killer whale DPS (*Orcinus orca*).

NMFS evaluated the proposed action for this consultation as a "mixed programmatic" action as defined by 50 CFR 402 because it includes some action components for which no additional authorization will be necessary and others that are considered at a framework-level. Components that require no additional authorization were analyzed during consultation and exemptions from take prohibitions provided in the incidental take statement of this Opinion. Action components that are considered at a framework-level are also analyzed in this Opinion, but with a broader scale of examination of the components' potential impacts on listed species and critical habitat. Exemption from take prohibitions are not provided for these components in the incidental take statement. Once framework-level components are developed at a more localized level and provide sufficient detail for take determination, they may require additional ESA section 7 consultation before implementation; this subsequent step-down consultation will include an incidental take statement for those components as necessary.

2.1 Overview of the Approach

NMFS uses the following approach to determine whether an action is likely to jeopardize listed species or destroy, or adversely modify, critical habitat:

- Describe the proposed action and identify the stressors created by the action.
- Identify the range-wide status of the species and critical habitat likely to be adversely affected by the proposed action.
- Describe the environmental baseline in the action area as defined in the ESA implementing regulations (50 CFR 402.02).
- Analyze the effects of the proposed action on both species and their habitat using an "exposure-response-risk" approach.
- Describe any cumulative effects in the action area.

- Integrate and synthesize the above factors as follows: (1) review the status of the species and critical habitat; and (2) add the effects of the action, the environmental baseline, and cumulative effects to assess the risk that the proposed action poses to species and critical habitat.
- Reach a conclusion about whether the proposed action is likely to jeopardize the continue existence of a listed species or result in the destruction or adverse modification of critical habitat.
- If necessary, suggest a reasonable and prudent alternative to the proposed action.

These sequential activities and analyses are illustrated in Figure 2 for listed species and Figure 3 for designated critical habitat, and described in more detail below.

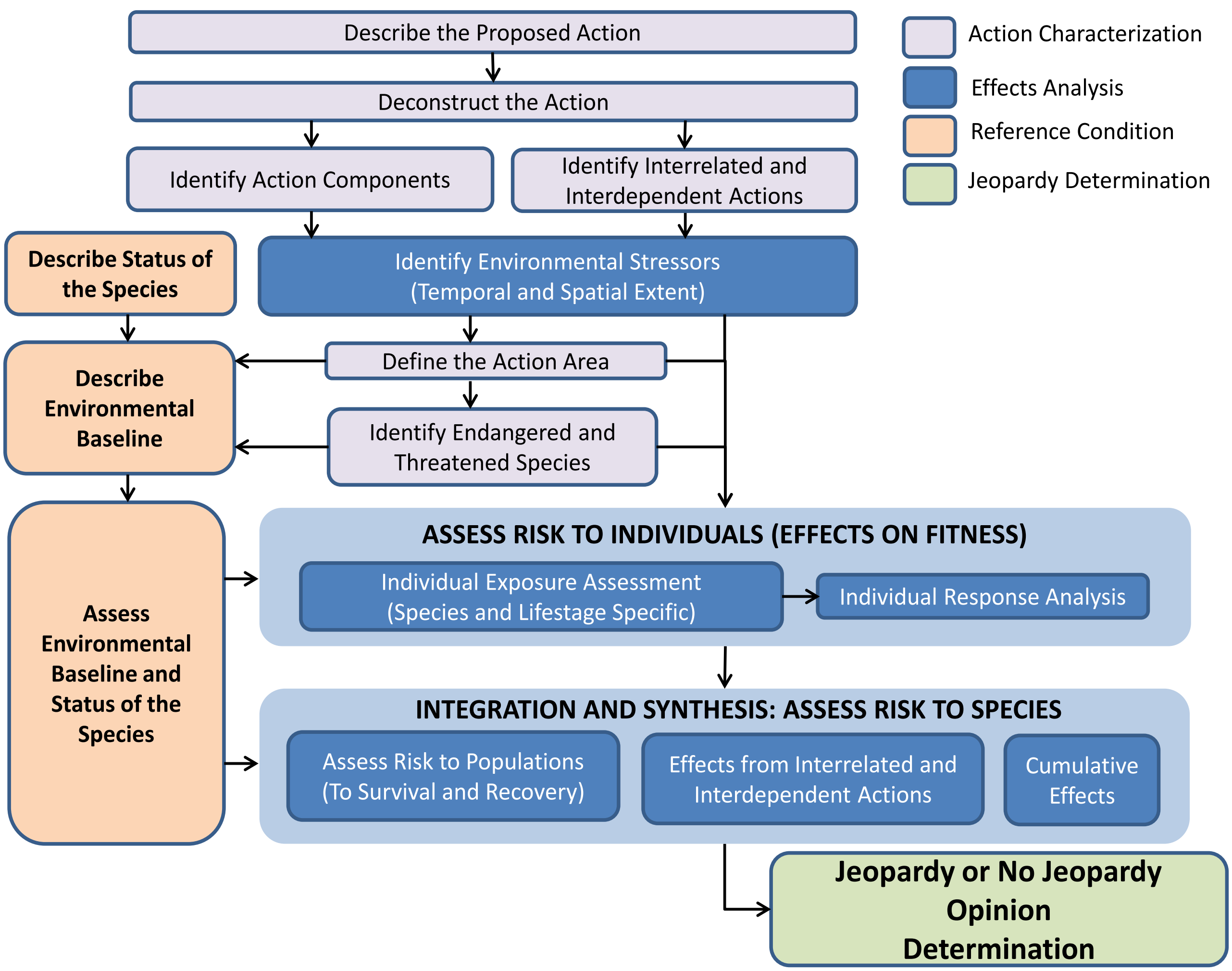


Figure 2. Conceptual model for conducting Endangered Species Act section 7 analyses for listed species.

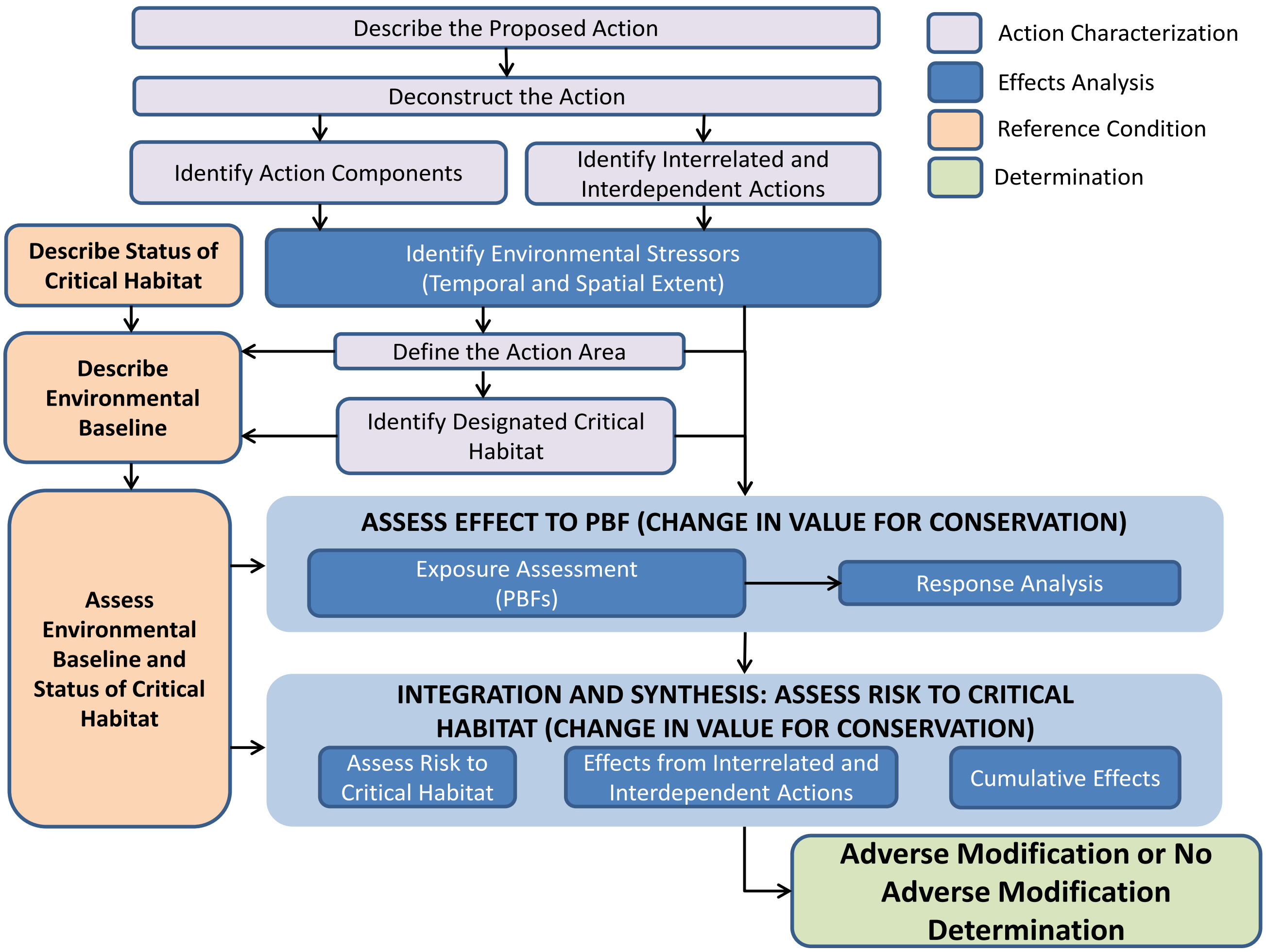


Figure 3. Conceptual model for conducting Endangered Species Act section 7 analyses for designated critical habitat.

Proposed Action and Stressors

In order for us to analyze the proposed action, it was first separated into components (deconstructed) for each Reclamation Division (as described in the biological assessment). The first analysis identified action components to identify stressors created by the proposed action. Here we define stressors as the physical, chemical, or biotic aspects of the proposed action that are likely to have individual, interactive, or additive direct and indirect effects on the environment (National Marine Fisheries Service 2004). As part of this step, NMFS identifies the spatial and temporal extent of both the action components and any potential stressors, recognizing that the spatial extent of the stressors may change with time, and that the spatial extent of potential stressors may extend beyond the geographic area included in the project description (e.g., if in-Delta operations may have effects that extend upstream, the upstream spatial extent of those effects was traced as part of this analysis).

Status of Species and Critical Habitat

The next step was to identify 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 describe the status of listed species throughout its range and in the action area.

Environmental Baseline

This step describes the past and ongoing factors leading to the current status of ESA-listed species and the condition of their critical habitat within the action area, including the past and present impacts of all federal, state, or private actions and other human activities in the action area, contemporaneous effects of state or private actions, and anticipated impacts of federal actions that have been consulted on.

Effects of the Action

We estimate the nature of co-occurrence of individuals and stressors as 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 physical or biological features of critical habitat that are likely to be affected. We then assessed the severity of an effect based on expected impact to the individual and its continued fitness or the expected impact to physical or biological features and value for conservation of critical habitat. Finally, we consider the incidence of exposure based on the activities in the description of the proposed action.

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. This represents the individual response analysis. 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 among species. These steps represent our risk analysis. They are different for listed species and designated critical habitat.

Cumulative Effects

This step summarizes the impacts of future non-Federal actions reasonably certain to occur within the action area. Similar to the rest of the analysis, if cumulative effects are expected, NMFS determines the exposure, response, and risk posed to individuals of the species and features of critical habitat.

Integration and Synthesis

The final step in the series integrates the conclusions drawn from these activities. 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 the precautionary principle. We summarize analyses in table format with consistent terms to facilitate the review of effects.

Conclusion

Considering the outcome of the integration and synthesis, in this step we reach a conclusion as to whether the proposed action reasonably would be expected to jeopardize the continued existence of listed species or destroy or adversely modify their critical habitats.

2.2 Application of the Approach to Listed Species Analyses

Our jeopardy determinations must be based on an 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.

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 proposed action implementation. The approach is described below for salmonids and sturgeon followed by the approach for SRKW.

2.2.1 The Viable Salmonid Populations Approach for Listed Fishes

For Pacific salmon, steelhead, and certain other species, we commonly use four "viable salmonid population" (VSP) parameters (McElhany et al. 2000) to assess the viability of the populations that, together, constitute the species. When these parameters are collectively at an appropriate level, 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 assessment considers and diagnoses both internal and external processes affecting a species' extinction risk.

Although McElhany et al. (2000) specifically addresses viable populations of salmonids, NMFS believes that the concepts and viability parameters in McElhany et al. (2000) can also be applied to the sDPS of green sturgeon due to the general similarity in life cycle and freshwater/ocean use. These parameters were used for considering demographic recovery criteria for green sturgeon by NMFS (National Marine Fisheries Service 2018f). Therefore, in this Opinion, NMFS applies the viability parameters (McElhany et al. 2000) in its characterization of the status of the species, environmental baseline, and analysis of effects of the action to the sDPS of green sturgeon.

Hierarchical Construct

As described above, we identify the risks that actions pose to listed individuals that are likely to be exposed to effects of the actions. Our analyses then integrate the individuals' risks to identify consequences to the proportion of populations represented by the individuals. Our analyses determine the consequences of those population-level risks to the species that the populations comprise.

To measure risks to listed individuals, we use changes in the individual's "fitness" as a metric. "Fitness" can be characterized as an individual's growth rate, survival probability, annual reproductive success, or lifetime reproductive success. In particular, during the individual 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 consequences for the individual's fitness.

When individuals are expected to experience reduced fitness, we expect those reductions to also reduce the population abundance or rates of reproduction or growth rates (or to increase the variance in these rates) (Stearns 1992). Reduction in one or more of these variables is a necessary condition for decreases in a population's viability, which is a necessary condition for decreases in a species' viability. 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 4).

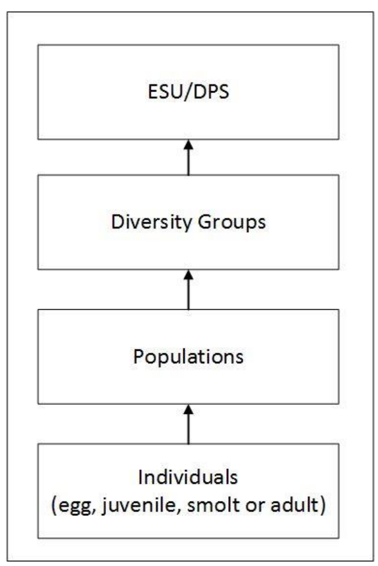


Figure 4. Hierarchical approach of analysis from individuals to species level.

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 and on the fitness and survival of individuals at the life stage scale. If we conclude listed individuals are likely to experience reductions in their fitness, we evaluate whether those fitness reductions are likely to decrease the viability of the populations those individuals represent, or to reduce 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.

An important tool in 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 the framework of this life cycle and 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 5 which shows the cycle of the upstream freshwater spawning, egg incubation, juvenile rearing, smoltification and outmigration[3], ocean residence, and upstream spawning migration. Though not identical, the life history of green sturgeon is similar (i.e., spawning in upstream freshwater locations, juvenile outmigration 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.

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. 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.

[3] The juvenile rearing and downstream movement life stage is intended to include fry emergence and fry and fingerling rearing, which occurs both in natal streams and as these fish are moving downstream through migratory corridors at a pre-smolt stage. The distinction between juveniles and smolts is made because smolts have colder thermal requirements than juveniles that are not undergoing osmoregulatory physiological transformations.

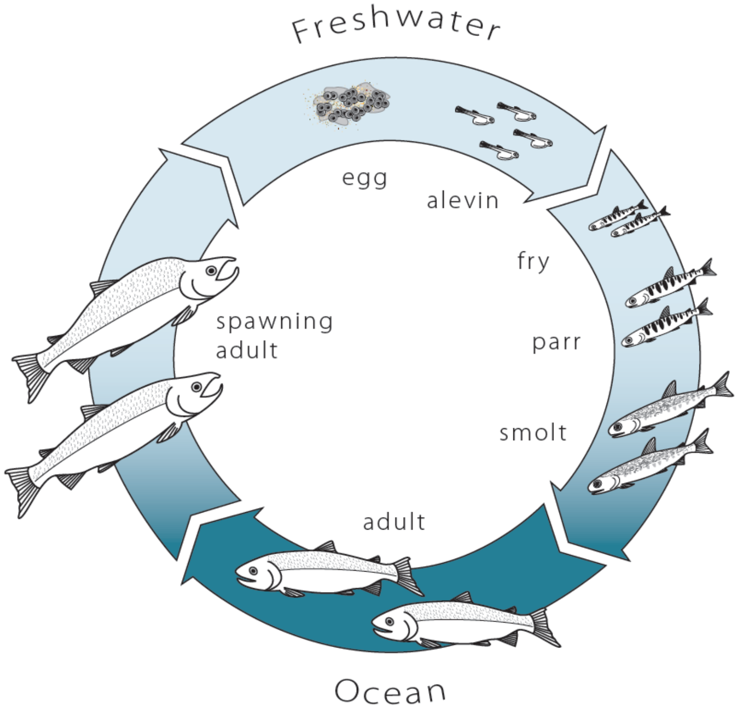


Figure 5. Life cycle of a pacific salmonid.

Determining Effects on Viability

The section 7 consultation process requires assessment of the effects of several stressors to the species. The effects of these stressors require conceptual understanding of both the species' use of the area and the effects of the stressors on the species. NMFS closely considered the conceptual models of the Delta Regional Ecosystem Restoration Implementation Plan (Williams 2010)and the Salmon and Sturgeon Assessment of Indicators by Life stage (SAIL) (Heublein et al. 2017; Johnson et al. 2017; Windell et al. 2017) when identifying and evaluating the effects of activities associated with the proposed action. These models identify the effects of stressors such as increased temperature, toxins, changes in flow, minor and major diversions, the site of action, and the life stage affected.

Our assessment next determines if changes in population viability are likely to be sufficient to reduce the viability of the species the population comprises. In this assessment, we use the species' status as our point of reference. We also use our knowledge of the population structure of the species to assess the consequences of the increase in extinction risk to one or more of those populations. Our status of the species section discusses the available information on the structure and diversity of the populations that comprise the listed species and any available guidance on the role of those populations in the recovery of the species. This information provides a sense of existing and lost diversity and structure within the species, which are important considerations when evaluating the recovery consequences of extinction risk or effects to habitat.

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 fitness 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). It is based on 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; level of benefit categories are high, medium, and low. High benefit addresses one or more lethal stressors such that individual survival is expected to increase. Medium benefit addresses one or more sub-lethal 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 (for the fish species) is characterized similarly as in (National Marine Fisheries Service 2009b) as large (70 percent or more exposed), medium (more than 2 percent, but less than 70 percent exposed), and small (exposure not expected to exceed 2 percent). We note that this includes intra-annual exposure (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 75 percent or more years), medium (moderately frequent; occurring in 25-75 percent of years), and low (infrequent; occurring in fewer than 25 percent of years). Table 3 shows combinations of severity, proportion, and frequency that result in the various magnitudes of effect.

Table 3. Categories of magnitude of effect based on the severity or benefit of a proposed action element and exposure.

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
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

The weight of evidence for stressor effect identified in Table 3 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

A key consideration in this assessment is the strategy of the NMFS recovery plan that "every extant population be viewed as necessary for the recovery of the ESUs and DPS," and that "wherever possible, the status of extant populations should be improved" (National Marine Fisheries Service 2014b). NMFS considers that an expected appreciable reduction in any population's viability due to implementation of the proposed action could also appreciably reduce the likelihood of survival and recovery of the population's diversity group and the ESU/DPS. In keeping with the precautionary principle, our analysis and assumptions generally give the benefit of the doubt to the species where there is uncertainty such that there is the possibility of harm from making a certain decision (e.g. taking a particular course of action) when extensive scientific knowledge on the matter is lacking.

There are, however, other considerations, including the timing, duration, and magnitude of the reduction and the permanent or temporary nature of the reduction. A proposed action could, therefore, adversely affect a population without appreciably reducing the likelihood of survival of the species.

VSP Parameters

In order to assess the survival and recovery of any species, a guiding framework that includes the most appropriate biological and demographic parameters is required. For Pacific salmonids, McElhany et al. (2000) defines a VSP as an independent population that has a negligible probability of extinction over a 100-year timeframe. The VSP concept provides specific guidance for estimating the viability of populations and larger-scale groupings of Pacific salmonids such as at the ESU or DPS level.

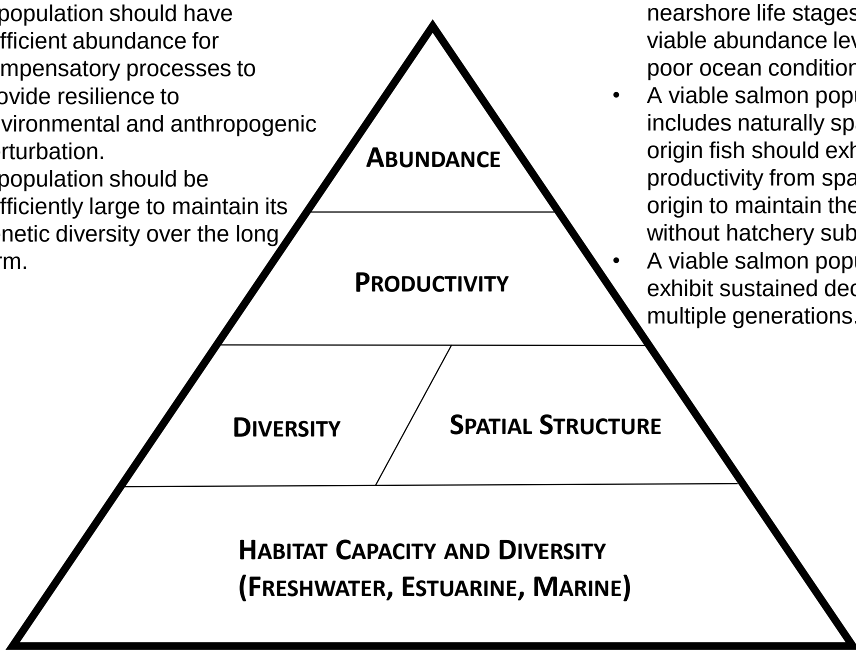
Four VSP parameters form the key to evaluating population and ESU/DPS viability: (1) abundance; (2) productivity (i.e., population growth rate); (3) population spatial structure; and (4) diversity (McElhany et al. 2000). These four parameters and their associated attributes are presented in Figure 6 (McElhany et al. 2000).

ABUNDANCE

- A population should be large enough to have a high probability of surviving environmental variation of the patterns and magnitudes observed in the past and expected in the future.
- A population should have sufficient abundance for compensatory processes to provide resilience to environmental and anthropogenic perturbation.
- A population should be sufficiently large to maintain its genetic diversity over the long term.

PRODUCTIVITY (POPULATION GROWTH RATE)

- Natural productivity should be sufficient to reproduce the population at a level of abundance that is viable.
- Productivity should be sufficient throughout freshwater, estuarine, and nearshore life stages to maintain viable abundance levels, even during poor ocean conditions.
- A viable salmon population that includes naturally spawning hatchery-origin fish should exhibit sufficient productivity from spawners of natural origin to maintain the population without hatchery subsidy.
- A viable salmon population should not exhibit sustained declines that span multiple generations.



DIVERSITY

- Human-caused factors such as habitat changes, harvest pressures, artificial propagation, and exotic species introduction should not substantially alter variation in traits such as run timing, age structure, size, fecundity (birth rate), morphology, behavior, and genetic characteristics.
- The rate of gene flow among populations should not be altered by human-caused factors.
- Natural processes that cause ecological variation should be maintained.

SPATIAL STRUCTURE

- Habitat patches should not be destroyed faster than they are naturally created.
- Human activities should not increase or decrease natural rates of straying among salmon sub-populations.
- Habitat patches should be close enough to allow the appropriate exchange of spawners and the expansion of population into underused patches.
- Some habitat patches may operate as highly productive sources for population production and should be maintained.
- Due to the time lag between the appearance of empty habitat and its colonization by fish, some habitat patches should be maintained that appear to be suitable, or marginally suitable, even if they currently contain no fish.

Figure 6. Viable Salmonid Population parameters and their attributes.

Source: (McElhany et al. 2000)

Criteria for VSP are based upon measures of the VSP parameters that reasonably predict extinction risk and reflect processes important to populations (National Marine Fisheries Service 2014b). 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).

Additional Considerations

In addition to the four key parameters, the quality, quantity, and diversity of the habitat (habitat capacity and diversity) available to the species in each of its three main habitat types (freshwater, estuarine, and marine environments) is a foundation to VSP. 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 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; Satterthwaite and Carlson 2015; Schindler et al. 2010; Yates et al. 2012). 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 (Koellner and Schmitz 2006; Markowitz 1952; Satterthwaite and Carlson 2015).

The foundation for this "portfolio effect" of spreading risk across populations can be found at the within-population scale (Bolnick et al. 2011; Greene 2009). 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).

The VSP concept also identifies guidelines describing a viable ESU or 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. 2007). Guidelines describing what constitutes a viable ESU are presented in detail in (McElhany et al. 2000).

Specific recommendations of the characteristics describing a viable Central Valley salmonid population are found in Table 1 of Lindley et al. (2007).

2.2.2 Approach Specific to Southern Resident Killer Whales

The Overview of the Approach and Application of the Approach to Listed Species Analysis described above also apply to NMFS' approach for Southern resident killer whales (SRKW). We used NMFS West Coast Region Guidance (National Marine Fisheries Service 2013) on how to identify key components and characterize the potential effects of the proposed action on SRKW in this consultation. The Southern Resident 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 2008b). 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. SRKW are known to prefer Chinook salmon as their primary prey (Ford and Ellis 2006; Hanson et al. 2010), and Southern Resident population dynamics have previously been correlated with the abundance of Chinook populations over a broad scale throughout their range (Ward et al. 2013). Prior sections have discussed the analytical approach to assessing impacts to ESA-listed Chinook salmon. Similarly, an accompanying analysis of impacts to non-ESA-listed Chinook salmon will be performed to support assessment of effects on SRKW prey base. This analysis of effects to Southern Residents 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 Southern Resident DPS.

2.3 Application of the Approach to Critical Habitat Analyses

The basis of the destruction or adverse modification analysis is to evaluate whether the proposed action affects the quantity or quality of the essential physical or biological features in the designated critical habitat for a listed species and, especially in the case of unoccupied critical habitat, whether the proposed action has any impacts to the critical habitat itself. Specifically, NMFS will conclude that a proposed action is likely to destroy or adversely modify the designated critical habitat for the ESU or 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 physical or biological features 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, and not on how individuals of the species will respond to changes in habitat quantity and quality. If an area encompassed in a critical habitat designation is likely to be exposed to the direct or indirect consequences of the proposed action on the natural environment, NMFS asks if physical or biological features included in the designation that give the designated critical habitat value for the conservation of the species 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 physical or biological feature or capacity of that habitat to develop those features over time.

To conduct this analysis, NMFS follows the basic exposure-response-risk analytical steps described in Figure 3. 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. For these reasons, some areas of critical habitat might respond to an exposure when others do not. We also consider how the physical and biological features of designated critical habitat are likely to respond to any interactions with and synergisms between cumulative effects of baseline conditions and proposed action stressors or benefits.

Hierarchical Construct

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 make up the designated area. In turn, the value of the watersheds or other areas is based on the quantity or quality of physical or biological features of critical habitat or capacity of that habitat to develop those features over time in that area. Some areas that are currently in a degraded condition may have been designated as critical habitat for their potential to develop or improve and eventually provide the needed ecological functions to support species' recovery. Under these circumstances, NMFS may conclude that an action is likely to "destroy or adversely modify" the designated critical habitat if the action alters it or prevents it from improving over time relative to its baseline condition.

Therefore, reductions in the quantity or quality of any physical or biological features 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.

Additional Considerations

We look to various factors to determine if the reduction in the quantity or quality of any physical or biological features 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 all critical habitat designated for the conservation of the species.

2.4 Evidence Available for the Analysis

The primary sources of initial project-related information was the ROC on LTO biological assessment, multi-agency meetings with the action agency to discuss project details and clarifications, and supplemental notes and data files provided by Reclamation. 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 the development of 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 and sDPS of green sturgeon
- Final rule describing the use of surrogates in incidental take statements (80 FR 26832)
- Final rule defining destruction or adverse modification of critical habitat (81 FR 7214)
- Final rule defining physical and biological features as replacements for primary constituent elements (81 FR 7414)
- 2016 5-year Status Review: Summary and Evaluation of Sacramento River Winter-run Chinook Salmon ESU
- 2016 5-year Status Review: Summary and Evaluation of CV Spring-run Chinook Salmon ESU
- 2016 5-year Status Review: Summary and Evaluation of CCV Steelhead DPS
- 2015 5-year Status Review: Summary and Evaluation of sDPS Green Sturgeon
- 2016 5-year Status Review: Summary and Evaluation of Southern Resident Killer Whale
- NMFS 2009 biological opinion on CVP and SWP operations and 2011 amendments to the reasonable and prudent alternative
- 2014 NMFS Recovery Plan for CV salmonids
- 2018 NMFS Recovery Plan for sDPS of green sturgeon
- 2008 NMFS Recovery Plan for Southern Resident killer whale
- Past independent reviews (i.e., CVP and SWP biological opinions, CVP/SWP operations biological opinion annual reviews,
- Two independent peer reviews of prior drafts of this Opinion)
- Technical recovery team "Framework for Assessing Viability of Threatened and Endangered Chinook Salmon and Steelhead in the Sacramento-San Joaquin Basin" (Lindley et al. 2007)
- Information included in Collaborative Science and Adaptive Management Program processes
- NMFS Selected Science Review for the Reinitiation Effort (Byrne 2018)

2.4.1 Conceptual Models and Stressor Linkages

To link proposed action components to the potential effects to the species and the species life-stage, NMFS 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 winter-run Chinook salmon. The Sacramento River provides spawning, rearing, and migratory corridor habitat for winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and the sDPS green sturgeon, and similar conceptual models can apply to all of these anadromous fish species. 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) are also explicitly linked to the primary stressors affecting the species identified in the respective recovery plans (National Marine Fisheries Service 2014b; National Marine Fisheries Service 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 egg incubation and alevin development stage 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 7, where the stars indicate factors that are directly influenced by management actions (n.b., the Tiers in the figures from Windell et al. (2017) are not the same as the operational Tiers included in the Summer Cold Water Pool Management component of the proposed action; they are common in terminology only). In this case, management actions are understood to have an influence on 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 storage/hydrology and Keswick releases likely contribute to the water temperature and water flow.

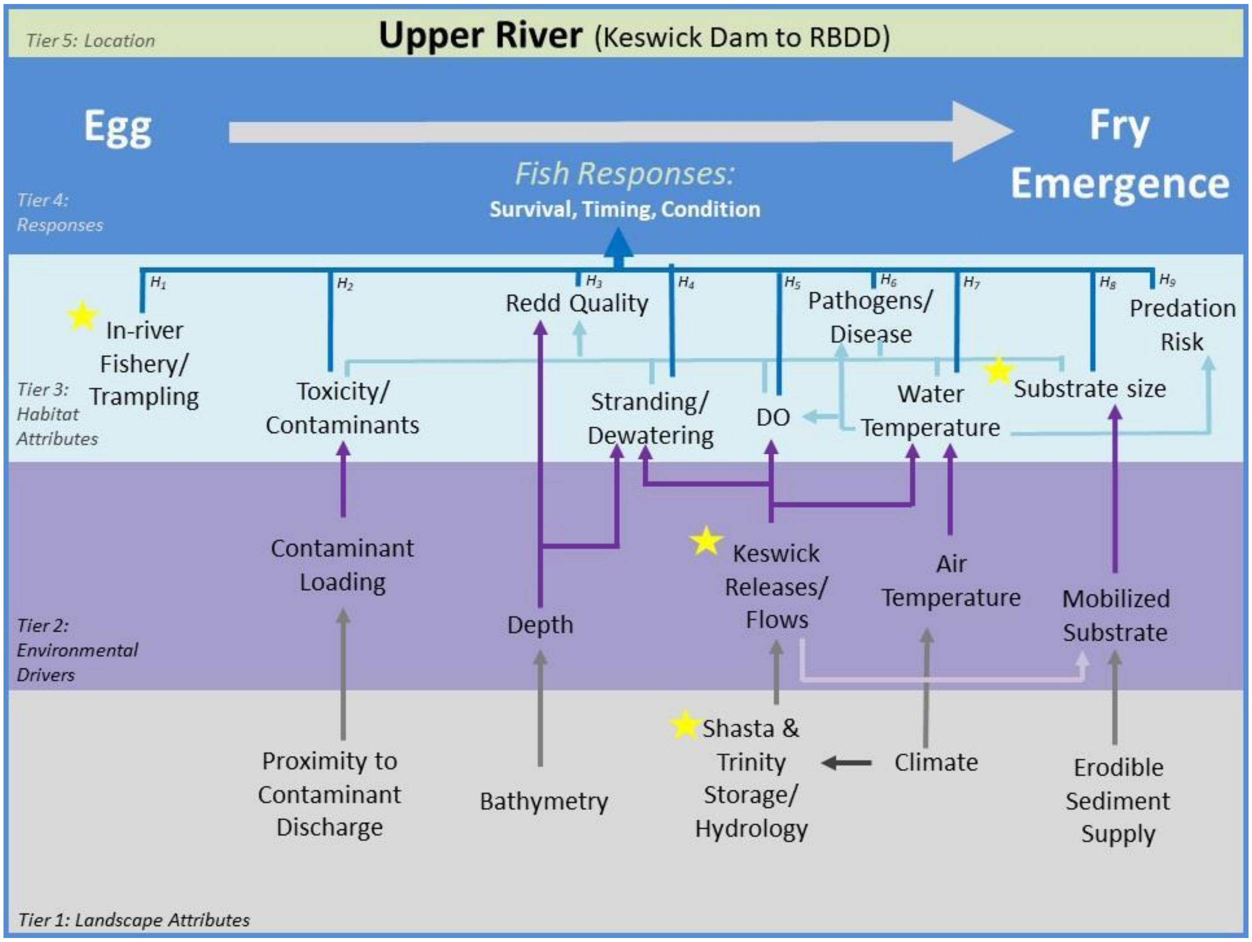


Figure 7. Conceptual model (CM1) of drivers affecting the transition of winter-run Chinook salmon from egg to fry emergence in the Upper Sacramento River. The stars indicate factors and pathways that are hypothesized to be influenced by management actions.

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 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 8, with stars indicating factors and pathways that are hypothesized to be influenced by management actions. These include Shasta and Trinity storage/hydrology, contaminant loading, fish assemblages, and Keswick Dam release/flows and irrigation diversions. For the life stage described in CM2, the attribute and driver of Shasta and Trinity storage/hydrology and Keswick Dam releases likely contribute to the water temperature and water flow stressors affecting recovery.

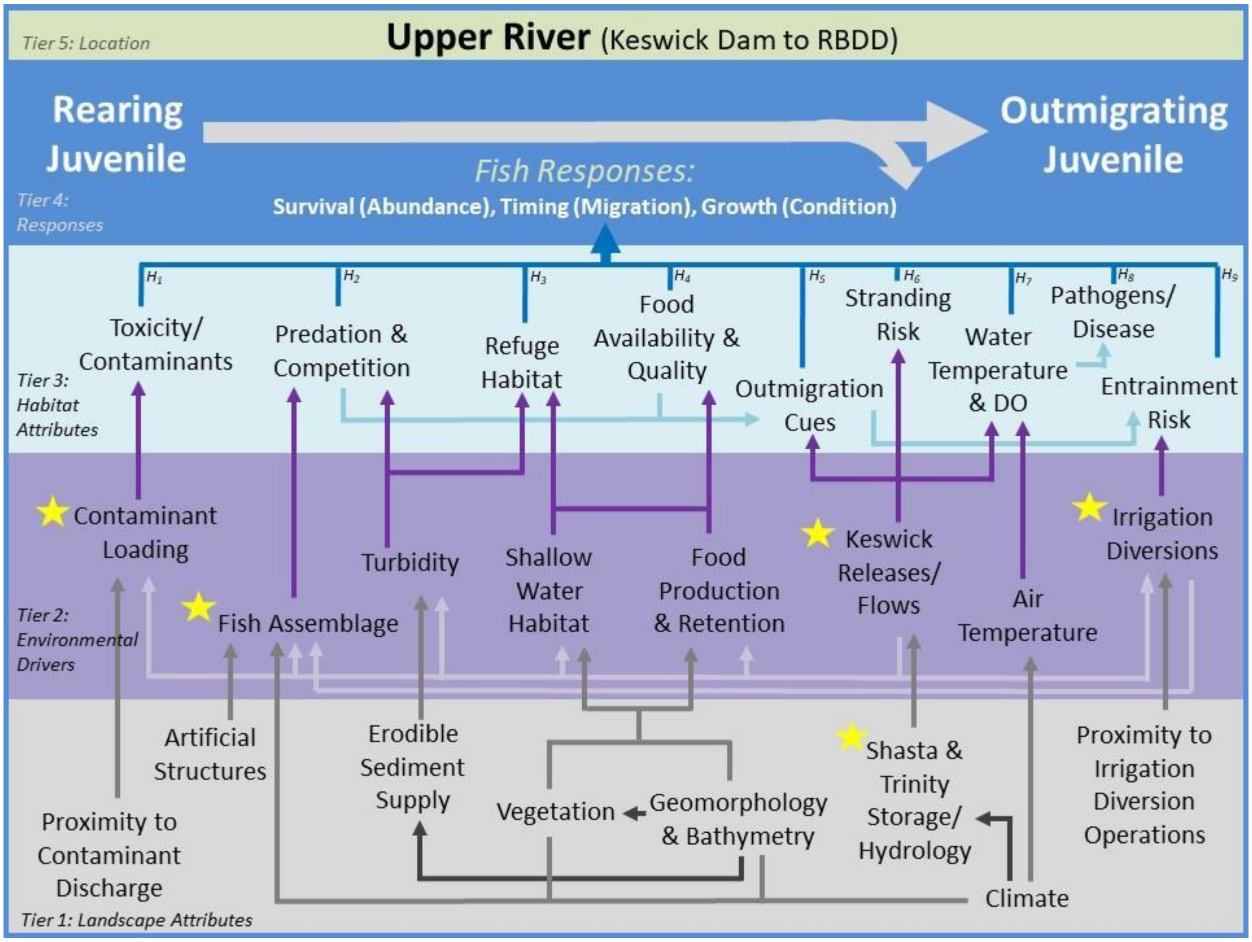


Figure 8. Conceptual model (CM2) of drivers affecting the transition of winter-run Chinook salmon from juvenile rearing to outmigration in the Upper Sacramento River. The stars indicate factors and pathways that are hypothesized to be influenced by management actions.

Source: (Windell et al. 2017)

The third SAIL conceptual model (CM3) defines juvenile rearing in the middle Sacramento River (Red Bluff Diversion Dam to Sacramento, including Sutter and Yolo Bypass) 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 9. During this period, the factors and pathways that are hypothesized to be influenced by management actions include contaminant loading, fish assemblages (including predators), 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.

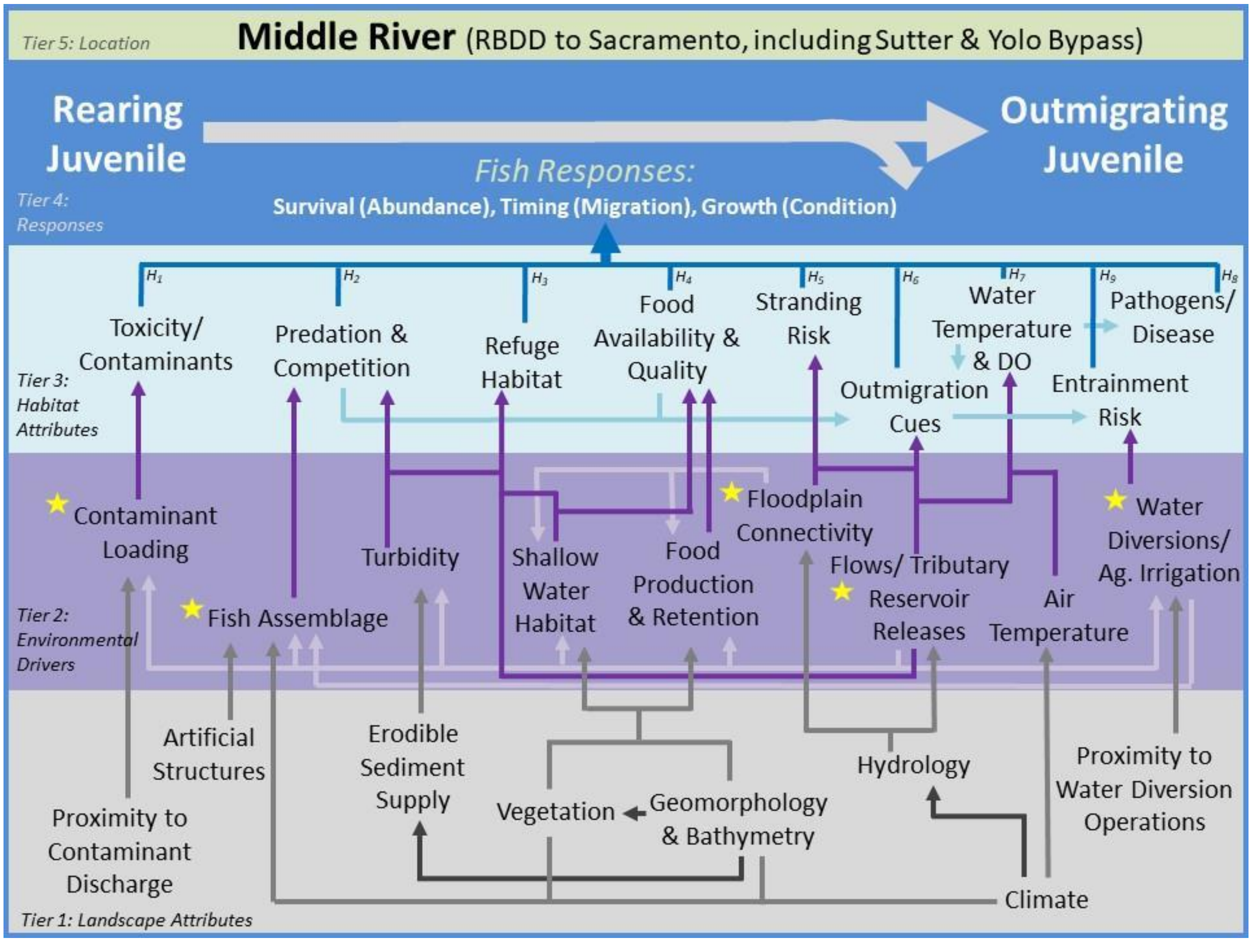


Figure 9. Conceptual model (CM3) of drivers affecting the transition of winter-run Chinook salmon from juvenile rearing to outmigration in the Middle Sacramento River. The stars indicate factors and pathways that are hypothesized to be influenced by management actions.

Source: (Windell et al. 2017)

The sixth SAIL conceptual model (CM6) defines adult 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 10. During this period, the factors and pathways that are hypothesized to be influenced by management actions include flood bypass weirs, Shasta and Trinity storage/hydrology, in-river fishery/poaching, and Keswick releases/Colusa Basin releases/flows. For the life stage described in CM6, the attributes and driver of Shasta and Trinity storage/hydrology, Flood Bypass Weirs, and Keswick releases/Colusa Basin Releases/Flows likely contribute to the water temperature, water flow, and spawning habitat availability stressors affecting recovery. The in-river fishery/poaching habitat attribute relates to the harvesting/angling impacts stressor.

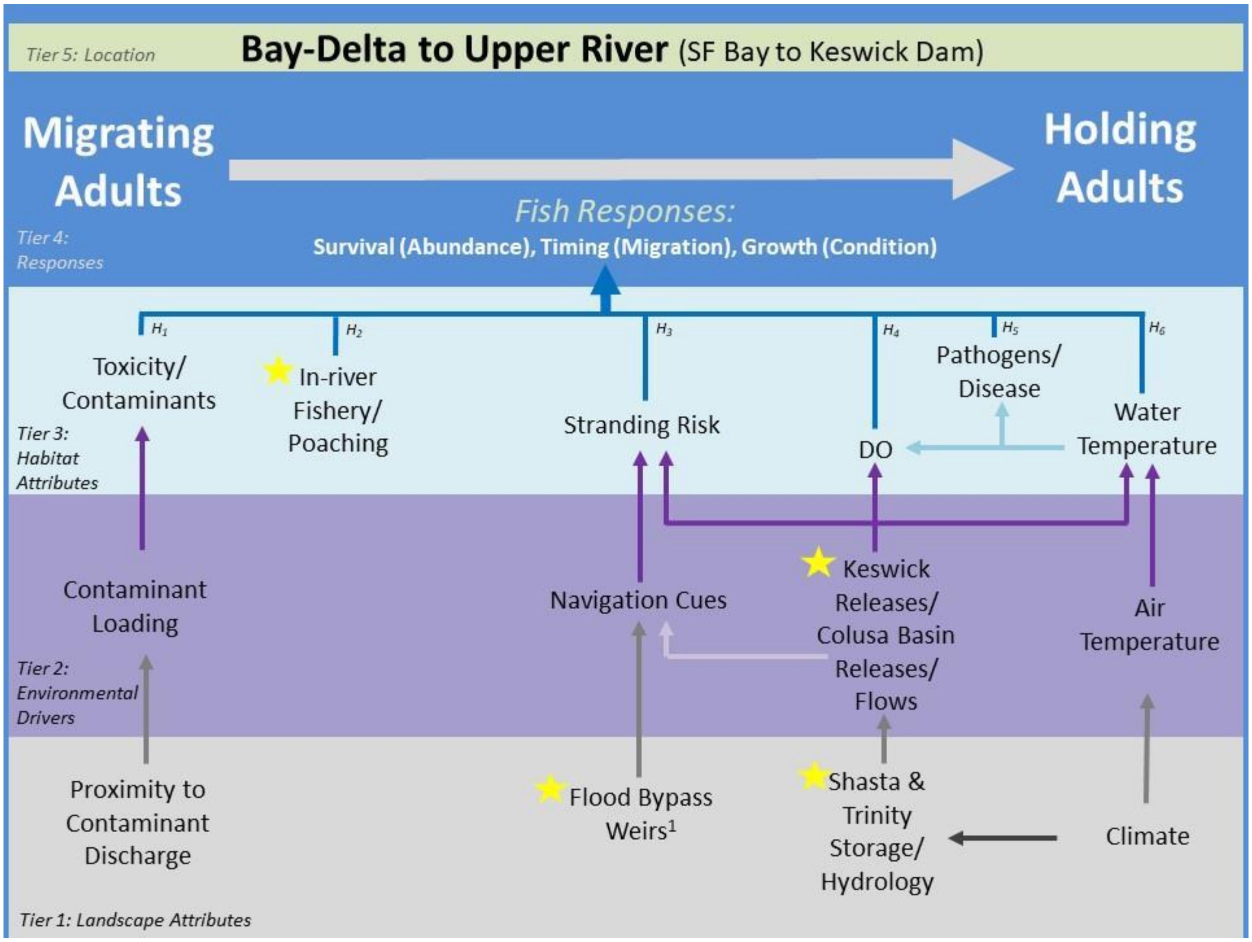


Figure 10. Conceptual model (CM6) of drivers affecting the transition of adult winter-run Chinook salmon from the ocean to the Upper Sacramento River. The stars indicate factors and pathways that are hypothesized to be influenced by managaement actions.

Source: (Windell et al. 2017)

The last SAIL conceptual model relevant to the Upper Sacramento/Shasta Division (CM7) defines adult 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 11. During this period, the factors and pathways that are hypothesized to be influenced by management actions include the hatchery broodstock program, Anderson-Cottonwood Irrigation Dam, Shasta and Trinity storage/hydrology, gravel quality & distribution/augmentation, Keswick releases/cold water storage/flows, and in-river fishery/poaching. For the life stage described in CM7, the attributes and driver of Shasta and Trinity storage/hydrology, temperature control device operations, and Keswick Releases/Cold Water Storage/Flows likely contribute to the water temperature, flow conditions, and spawning habitat availability stressors affecting recovery. The Anderson-Cottonwood Irrigation District Dam 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.

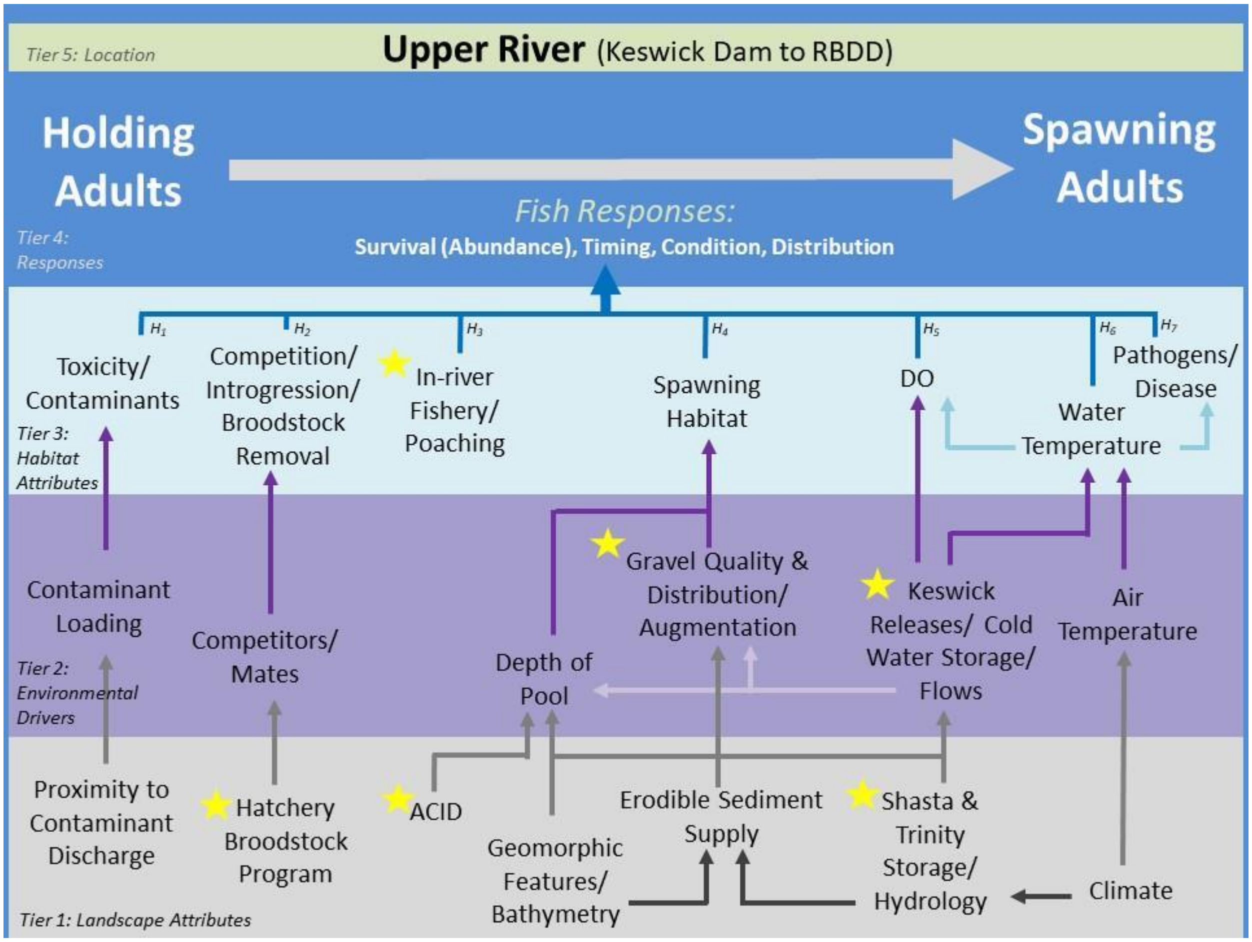


Figure 11. Conceptual model (CM7) of drivers affecting the transition of holding to spawning for adult winter-run Chinook salmon in the Upper Sacramento River. The stars indicate factors and pathways that are hypothesized to be influenced by management actions.

Source: (Windell et al. 2017)

A conceptual deconstruction of the action (see Figure 38 for the Shasta Division as an example) is informative in describing further the relationships between various processes and outcomes. proposed action components that reduce in river flows such as the winter minimum flows help to build Shasta storage, which increases the likelihood of meeting temperature targets in-river/below dams in the summer as part of summer cold water pool management. Likewise, proposed action components that increase seasonal flows, such as releases to support the diversion of water supplies under contracts and meet other requirements in the Delta, can reduce storage and the likelihood of meeting summer temperature requirements.

Sometimes this relationship is explicit in the proposed action and biological assessment analysis, as seen in fall and winter refill and redd maintenance, where Reclamation proposes to set the

Keswick Dam fall release schedule based on Shasta end of September storage. In this case, Reclamation is proposing a range of Keswick releases and fall flows that are defined by Shasta end of September storage; higher end of September storage corresponds to higher fall flows because the need to actively build storage in the fall is relaxed.

2.4.2 Primary Analytical Models

The ROC on LTO biological assessment 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 listed below. Models with an asterisk (*) denote models specific to this consultation that were not in the biological assessment submission. These models were provided to NMFS by Reclamation at NMFS' request. NMFS did not develop new scenarios for analysis; that is, the biological assessment included modeling of two scenarios (a proposed action and a current operations scenario), and NMFS analyzed the results of these scenarios. Not all tools were used in all Divisions, as some are only applicable to certain rivers or geographic areas. Fundamental models used in the Opinion include the following:

- CalSimII: A hydrological planning scenario tool that provides monthly average flows for the entire SWP and CVP system based on an 82-year record.
- DSM2: One-dimensional mathematical 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 "Simulation of Flood Control and Conservation Systems": 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. It uses CalSimII 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.
- SALMOD*: Predicts effects of flows on habitat suitability and quantity for all races of Chinook salmon in the Sacramento River.
- 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.
- IOS*: A stochastic life cycle model for winter-run Chinook salmon the Sacramento River.

- Salvage-Density Analysis*: A model of entrainment into the south Delta facilities as a function of flow based on historical salvage data.
- NMFS-Southwest Fisheries Science Center Temperature Dependent Egg Mortality Model (Martin et al. 2017): A temperature-dependent mortality model for Chinook salmon embryos that accounts for the effect of flow and dissolved oxygen on the thermal tolerance of developing eggs.
- Sacramento River Winter-run Chinook Salmon Life Cycle Model (WRLCM)*: A state-space and spatially explicit life cycle model of eggs, fry, smolts, juveniles in the ocean, and mature adults that includes density-dependent movement among habitats.
- Anderson Egg Mortality Model: Models for managing the Sacramento River temperature during the incubation of winter-run Chinook salmon which characterize temperature-and density-dependent mortality from egg through fry survival.
- Weighted Usable Area*: A computation of the surface area of physical habitat available weighted by its suitability according to studies assessing suitability of physical and (at times) chemical factors such as substrate particle size, water depth, flow velocity, and dissolved oxygen.
- 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.
- STARS Model (Perry et al. 2019): Survival, Travel Time, and Routing Simulation model developed by 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.

Figure 12 provides a schematic of how the models relate to each other in terms of information flow. Because the CalSimII modeling characterized a projected 2030 climate scenario, that climate condition was represented in all “downstream” modeling that used the CalSimII results.

Several of these models have not been updated to be recalibrated to recent data, especially that of the recent drought. This does introduce an additional component of uncertainty to their application, however, these tools still represent the best options available to NMFS for use in this analysis. Given the approach of applying them to an 82-year sample set of hydrologies, we believe that the tools capture the effects of the majority of years.

NMFS has developed a life cycle modeling framework for CV Chinook salmon that was used in this consultation to allow better evaluation of how complex and interacting management actions affect salmon populations. Specifically, the analyses included results from a model framework developed by the NMFS Southwest Fisheries Science Center to describe salmon population dynamics given water management, habitat restoration, and climate change scenarios (Hendrix et al. 2014; Hendrix et al. 2017). The model relied upon standard Central Valley physical (i.e., CalSimII, DSM2-HYDRO, 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.

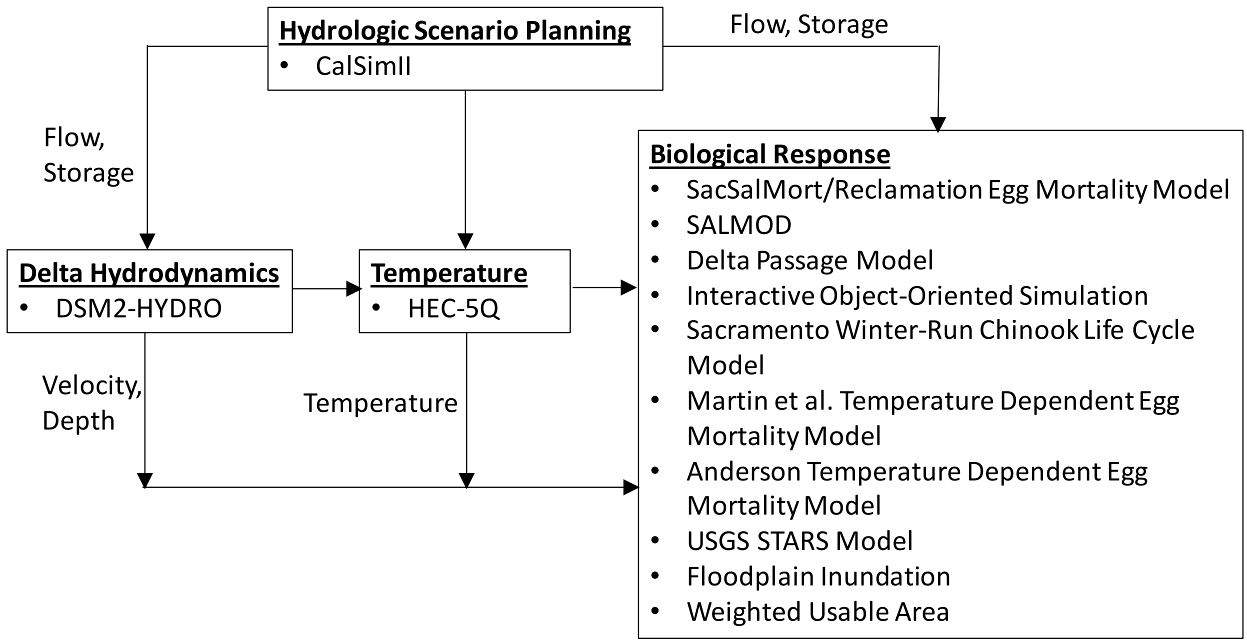


Figure 12. Primary models used in the analysis and their relationships.

The physical models applied in the biological assessment 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, CalSimII is a monthly planning model and cannot be used in a real-time predictive manner. CalSimII 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 CalSimII 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.

Given the nature of modeling outputs and historical data, throughout consultation we often analyzed effects in a comparative analysis between proposed action and current operations scenarios, or in relation to baseline conditions to place the difference in context given conditions and operations in the last decade. And although the results of the analytical tools required a more comparative analysis, the analysis for section 7 consultation requires that the effects of the project be evaluated in the aggregate. Our analysis culminates in an aggregate assessment in the integration and synthesis to draw conclusions according to the ESA. Therefore, NMFS used the results of the analysis in the exposure-risk-response 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.

The analyses presented in this Opinion for the Shasta, Trinity, American, Delta and Eastside Divisions draw upon different models and information sources that have different applications based on the action component being evaluated. In some cases, several models are used to evaluate the effects of the proposed action in relation or in contrast to the current operating scenario with the goal of either isolating absolute project-specific effects or analyzing the trend of the effect over time. In other cases, species-specific habitat requirements obtained from scientific literature are used to evaluate the effects of the proposed action. With action components and stressors differing across Divisions, different approaches are required to evaluate the effects of the proposed action.

2.4.3 Modeling of Potential Effects

All modeling reflects the incorporation of a 2030 scenario of climate conditions, water demands, and water allocations as proposed in the biological assessment. Therefore, the evaluation implicitly includes a climate change condition. However, considering the 4th California Climate Assessment, NMFS expects that in-river temperatures will be even greater than what was presented in the biological assessment modeling. NMFS cannot quantify the effect of this on species, but will assume that the provided modeling represents a scenario of lower effect and will layer additional qualitative evaluations of increased climate effects to the species based on the updated assessments. Regarding sea level rise, NMFS considers the modeling of the proposed action as the scenario of lower effect and consistent with the 4th California Assessment for 2030; however, it is considered as an absolute lower effect for late 2000s when the assessment projects much greater increases than those captured in the modeling of 2030 in the biological assessment.

Detailed descriptions of the modeling used to inform the effects analysis are available as appendices to this Opinion. Specifically, Appendix A is the model description for the Sacramento River Winter-run Chinook Salmon Life Cycle Model (WRLCM). Appendix B provides descriptions of the Delta Passage Model, the Interactive Object-Oriented Simulation (IOS) and the SALMOD Model. These were extracted from Appendix 5.D of U.S. Bureau of Reclamation (2016a) because the same methods, without modification, were applied in Reclamation’s analysis of that project and the documentation is still accurate. Likewise, Appendix C, describing the Salvage Density Model, was also extracted from the CWF biological assessment Appendix 5.D. Appendix D contains a description of the Reclamation Salmon Mortality Model (SacSalMort) which was included in Attachment 5.D.1 of the ROC on LTO biological assessment. Lastly, Appendix E describes the methods used for the Science Integration Team’s Model Floodplain Habitat Analyses for the rivers and bypasses considered in the analysis of the ROC on LTO.

2.4.4 Assumptions in the Analysis

To address uncertainties related to the proposed action and the analysis provided in the biological assessment, NMFS used its professional judgement to establish a set of reasonable assumptions required to address existing data gaps in the biological assessment that were used in 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 for the duration of the proposed action, defined as 2030. The proposed action and Opinion analyses characterize water demands and build-out as predicted for approximately 2030, and project climate conditions into the reasonably foreseeable future.
- The project, as characterized in the modeling provided by the biological assessment, does not simulate short-term real-time operations, especially those that are dependent on biological triggers. Because the modeling analysis was based on comparative long-term scenario planning tools, it was not able to emulate the daily operations that would be implemented to manage to biological, water quality, and other constraints
- 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.
- Components of the proposed action presented without sufficient specificity to analyze defined potential effects were analyzed as framework-level action components. For components of the proposed action that lacked the specificity required to analyze a particular effect in detail, NMFS took a reasonably conservative approach to analyzing the range of effects that could result. Generally, such effects were considered in terms of the direction and potential magnitude of effect, but due to the uncertainty associated with such actions they were not relied on heavily to reach our conclusions. Exposure of a few individuals to a stressor, as indicated by the species presence, does not result in no adverse effect. Exposure of a small number of individuals may still result in incidental take of those individuals.

2.4.5 Upper Sacramento/Shasta Division Uncertainties

NMFS has identified sources of uncertainty, which are identified in Table 4, that are considered in the evaluation of effects of the proposed action components for the upper Sacramento/Shasta Division. Table 4 includes uncertainties related to modeling limitations, alternative analytical tools, and real-time implementation of the proposed action, noting the information provided by Reclamation, and the assumptions we have applied in addressing the uncertainty.

Table 4. Sources of uncertainty associated with analysis of the proposed action operations of Shasta Dam and the upper Sacramento River.

Source of Uncertainty	Information from biological assessment and Supplemental Reclamation Submissions	How NMFS Applied Assumptions to Address Uncertainty
Mathematical modeling of current operations scenario	Model parameters that control the amount of Shasta releases for various purposes and these can directly affect storage conditions, the current operating scenario does not explicitly include the storage components of the RPA of the NMFS 2009 Opinion due to uncertainty in operationalizing the RPA in the CalSimII model. Storage not always met with the frequency assumed in the RPA.	Because storage components from the RPA are not always met, NMFS assumed the current operating scenario modeling represented lower storages than expected in current conditions. We used the historical as the bottom range of the likely Tier frequency in the analysis
Mathematical modeling of the proposed action	Years are considered to be within Tier 1 despite exceedances of 53.5°F daily average temperature in over 20 percent of modeled days; proposed action assumes that real-time operations will allow avoiding exceedances.	NMFS considers that operations may not exactly achieve 53.5°F, or as described in other tiers at the specific location of all fish. NMFS assumes that Reclamation's operational flexibility will minimize the frequency and magnitude of exceedances that would compromise the objective of the given Tier.
Modeling of the proposed action and the current operating scenario	Climate change is incorporated using CMIP3 and AR3, which does not reflect the most current available science for temperature increases.	Assumed that the provided modeling represents a scenario of limited effects of climate change to the species; NMFS layers additional qualitative evaluations onto quantitative analyses to reflect greater projected changes in temperature and sea level rise in CMIP5 modeling.
Biological Modeling	Anderson (2018) model simulates egg to hatch through life stage-dependent temperature mortality and the spatially dependent background mortality from hatch through fry stages. The Anderson model assumes that redds/eggs are most sensitive to dissolved oxygen conditions during the five days preceding hatch and results include mortality only for that period. Both Anderson and Martin biological models rely on field observations that cannot reliably distinguish temperature- related egg mortality from other sources of mortality and do not account for uncertainty associated with monitoring	In considering differences between results from the Anderson and Martin models, NMFS considers that the Anderson model could underestimate mortality by not accounting for egg mortality prior to the hatch period in the percentage mortality during the hatch period. Results for both models are considered in the effects analysis.

Source of Uncertainty	Information from biological assessment and Supplemental Reclamation Submissions	How NMFS Applied Assumptions to Address Uncertainty
	Anderson model is based on previous (Rombough 1994) analyses, but has not completed a published peer-review process. Martin model is based on a meta analysis of fishery information and has completed the peer-review process.	Considered external reviews and field-testing in assigning weight of evidence applied to methods according to categories identified in Section 2.1 Analytical Approach. Acknowledges the uncertainties and needs for additional research identified in review of Martin et al. (2017) but also that it is a "realistic representation of temperature effects on eggs" (Gore et al. 2018).
Uncertainty During Real-Time Implementation of Proposed Action	Annual and seasonal uncertainties with precipitation and runoff, air temperatures, and cloud cover.	NMFS considers that the water temperature that fish experience may exceed 53.5°F, or other temperatures as described in other tiers.
	Uncertainty about forecasted temperature control device performance.	NMFS considers that the water temperature that fish experience may exceed 53.5°F, or other temperatures as described in other tiers.
	Assumptions about actual accretions and depletions in upper Sacramento River may not be accurate	NMFS considers that the water temperature that fish experience may exceed 53.5°F, or other temperatures as described in other tiers.

A specific example of uncertainty related to real-time implementation of the proposed action is the exposure risk to temperature conditions during summer temperature management. For current operations, Reclamation takes a conservative approach to building storage that starts by targeting minimum flows in the fall and winter until either the reservoir nears the flood control elevation or another requirement, such as Delta water quality, requires increased releases of stored water. With this approach, Reclamation develops a monthly Keswick Dam release forecast using the Shasta end of September carryover storage and various historical hydrologies. The current operations include an interagency workgroup that provides input to Reclamation on taking additional actions, including export curtailments, if necessary, to conserve storage and other protections/measures. Similarly, for the proposed action action component fall and winter refill and redd maintenance, Reclamation is proposing to set minimum fall flows according to Shasta end of September carryover storage.

Reclamation will coordinate under all conditions, and seek technical assistance from NMFS and the FWS regarding species intervention measures only in the driest of the four proposed Tiers (i.e., March 90 percent exceedance runoff forecast indicate May 1 Shasta storage of less than 2.5 MAF). In contrast, the existing process includes monthly consultations between NMFS and Reclamation from the February forecast through the issuance of the Sacramento River temperature management plan in May. These consultations provide NMFS with the opportunity to provide information regarding biological criteria for spring operations of Keswick Dam releases, with the intent of reducing negative effects of increased temperature on winter-run Chinook salmon while still accommodating other legal and delivery requirements.

The proposed action included deliveries to all CVP contractors, including implementation and performance of the north-of-Delta settlement contracts. Therefore, we evaluate the full effects of maximum water deliveries and diversions under the terms of existing contracts and agreements, including timing and allocation in this Opinion, as well as other obligations, including D-1641, refuge supplies, and exchange contractor deliveries.

While the current operating scenario is intended to represent the current operating criteria (i.e., operations that comply with the FWS 2008 and NMFS 2009 opinions), the current operating scenario does not include year-specific adjustments, modified drought requirements, maintenance of facilities, facility malfunctions, or other short-term or unforeseen actions that change real-time operations. NMFS has identified ways in which the current operating scenario CalSimII modeling deviates from a description of actual current operations. There are, therefore, ways in which the current operating scenario does not fully characterize the historical operations of the last ten years under the NMFS 2009 Opinion. Modeling for the current operating scenario does not explicitly prioritize releases from Folsom and Oroville reservoirs (rather that Shasta releases) per specific 2009 RPA elements to meet in-Delta water quality or flow requirements, though it does consider relative reservoir storage when determining releases for in-Delta needs. For the purposes of comparing the proposed action to current operations, NMFS has assessed effects of building storage relative to coordinated use of Oroville releases. Additionally, the current operating scenario model does not reflect management options to limit Keswick Dam releases to 7,500 cfs or less in July of dry and critical years, and the model is not capable of characterizing particular temperature operations or the ability to change temperature targets throughout the year. All of these actions have the potential to result in increased coldwater pool in Shasta Reservoir in the spring period. NMFS has used this information in better understanding the resulting comparisons of Shasta Reservoir storage for the proposed action versus the current operating scenario and placing that in context given conditions and operations in the last decade.

2.5 Supplemental Analysis of Revised Proposed Action

During consultation discussions between NMFS and Reclamation resulted in revisions to the proposed action that were not captured in the February 5, 2019, biological assessment that was used for the majority of the analysis in this Opinion. As described in the introduction, the proposed action has been revised multiple times during the ongoing consultation to address aspects of the February 5, 2019 proposed action that were unclear or confusing, to reduce uncertainty, improve protections reduce and to provide additional benefits for fish. The effects description and analyses were first based on the modeling associated with the February 5, 2019 proposed action ((U.S. Bureau of Reclamation 2019c), the original proposed action) and associated modeling that NMFS requested. Later revisions to the proposed action were not able to be captured in the quantitative modeling. However, these changes are reflected in the final proposed action (U.S. Bureau of Reclamation 2019b), and were included in our analysis as a qualitative discussion of whether and how the proposed action revisions modify the effects analyzed in the models. Additional actions agreed to by the SRS Contractors during consultation were similarly qualitatively factored into the analyses in this Opinion.

2.6 Consideration of Climate Change

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. In addition, 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 guidance for treatment of climate change in ESA decisions (Sobeck 2016). This guidance notes the need to consider climate change in determinations and decisions despite the challenges of climate change uncertainty.

In addition to Sobeck (2016), NMFS regional guidance (Thom 2016) further recommends use of the Representative Concentration Pathway (RCP) 8.5 scenario from the Fifth Assessment Report (AR5). Sobeck (2016) notes that "when data specific to (the RCP 8.5) pathway are not available, (NMFS) will use the best available science that is as consistent as possible with RCP 8.5." This RCP is characterized by increasing greenhouse gas emissions over time, representative of scenarios in the literature that lead to high greenhouse gas concentration levels (Riahi et al. 2007).

Climate change is incorporated into this analysis implicitly to an extent by the modeling results provided in the biological assessment and additionally by qualitative evaluations that reflect more recent climate predictions. The modeling of the proposed action as provided in the biological assessment characterizes a 2030 scenario of climate conditions, water demands, and build-out to full water contract capacities. In doing so, the proposed action uses a multi-model ensemble-informed approach to identify a best estimate of the consensus of climate projections from the third phase of the Coupled Model Intercomparison Project (CMIP3), which informed the Intergovernmental Panel on Climate Change's (IPCC) Fourth Assessment Report (AR4). These results are downscaled to a spatial resolution of approximately 12 km. This assessment report and approach results in an anticipated temperature change of +0.7 to +1.4 degrees Celsuis (°C; 1.26 to 2.7 degrees Farenheit (°F), representing the 25th to 75th quartile) and a precipitation change of -6 percent to +6 percent. Additionally, the approach used for the proposed action characterizes 2030 sea level rise of 15 cm. Based on results from the application of RCP 4.5 and RCP 8.5 in California's Fourth Climate Change Assessment (He et al. 2018; Pierce et al. 2018), NMFS expects that climate conditions will follow a more extreme trajectory of higher temperatures and shifted precipitation into 2030 and beyond. As provided by the assessment, NMFS assumes that temperatures would increase up to 1.9°C (3.4°F) 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 cm in 2030 and 10 to 38 cm in 2050 (Pierce et al. 2018).

Modeling for the proposed operations that uses data specific to RCP 8.5 is currently unavailable. Therefore this consultation assumes that the provided modeling represents a best-case scenario regarding climate conditions through 2030 and, to account for the differential in increased temperature, shifted precipitation, and projected sea level rise between the CMIP3 and California's Fourth Climate Change Assessment, NMFS will layer qualitative evaluations of increased climate effects onto the provided modeled data. This is consistent with guidance that "NMFS does not need to know with precision the magnitude of change over the relevant time period if the best available information allows NMFS to reasonably predict the directionality of climate change and overall extent of effects to species or its habitat" (Sobeck 2016).

3 Proposed Federal Action

"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, with DWR, requested the reinitiation of consultation on long-term operation of the CVP and SWP in part because of the substantial amount of new information and science that has been developed since the 2009 Opinion. Reclamation and DWR propose to continue the coordinated long-term operation of the CVP and SWP through 2030 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. Reclamation and DWR propose to 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.

Reclamation and DWR developed the January 2019 version of the proposed action (U.S. Bureau of Reclamation 2019c) in response to new information and science allowing them to provide better conditions for protected species while also maximizing operational flexibility to deliver water to water users through 2030.

This Opinion evaluates Reclamation's final proposed action of October 17, 2019. The Service recognizes that Reclamation is continuing to evaluate the proposed action and other alternatives pursuant to the National Environmental Policy Act. If the proposed action changes through the NEPA process beyond the effects analyzed in this consultation, NMFS anticipates that Reclamation will reinitiate consultation on the modified proposed action, as appropriate.

Both NMFS and the FWS identified uncertainties related to aspects of the proposed action and Reclamation's biological assessment of the effects of its action. These identified uncertainties related to modeling limitations, alternative analytical tools, the lack of specific metrics, and information Reclamation provided regarding real-time implementation of the proposed action. In particular, NMFS concluded that there was notable uncertainty regarding Reclamation's ability to considerably increase total Shasta storage on May 1 under the proposed action. During consultations, FWS and NMFS both expressed concerns about Delta operations. This uncertainty was reflected in in previous drafts of this Opinion.

In response, through ongoing consultation, Reclamation added certainty through additional commitments to improve conditions for listed species, and clarified confusing language. These changes include: clarifying that Reclamation uses a conservative forecast for allocations; better defining the spring pulse; and adding additional commitments regarding cold water pool management and loss thresholds for Old and Middle River operations.

3.1 Upper Sacramento/Shasta Division Operations

Reclamation operates the Shasta Division of the CVP for multiple purposes, including flood control, agricultural water supplies, municipal and industrial water supplies, fish and wildlife, hydroelectric power generation, navigation, Delta water quality, and water quality in the upper Sacramento River. Facilities include the Shasta Dam, Lake (4.552 million acre-feet 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 Reclamation to control the temperature of the water released from Shasta Dam. The temperature control device gives Reclamation the option to draw from the lowest (and coldest) possible water from the reservoir. Reclamation must balance the objectives of pulse flows or water supply releases early in the season with the goal of maintaining a cold water pool sufficient to meet fish species' needs toward end of spawning and incubation season in the fall.

Reclamation operates in the winter for flood control, considering both the channel capacity within the Sacramento River and Shasta Reservoir flood conservation space. When not operating for flood control, Shasta Dam is operated primarily to conserve storage while meeting minimum flows both down the Sacramento River and in the Delta. During the summer, operational considerations are mainly flows required for Delta outflows, instream demands, temperature control, and exports. Fall operations are dominated by temperature control and provision of fish spawning habitat.

Proposed Action Components

Reclamation proposes the following specific actions in addition to current ongoing operations.

3.1.1 Cold Water Pool Management

The proposed action proposes to improve cold water pool management so that Shasta Reservoir is generally held higher than under current operations by May 1. This approach will allow Reclamation to better manage the limited cold water resource to improve Winter-run Chinook salmon egg survival. The tiered approach recognizes the substantial influence of hydrology on available cold water and targets a temperature of 53.5°F in the upper Sacramento River above Clear Creek at the Clear Creek California Data Exchange Center temperature gauging station from May 15 to October 31. Reclamation would manage water temperatures based on the following tiers:

- Tier 1 – Targets 53.5°F or lower starting May 15
- Tier 2 – Targets 53.5°F during critical egg incubation period
- Tier 3 – Targets 53.5-56°F during critical egg incubation period; consider intervention measures in lower Tier 3 years
- Tier 4 – Targets 56°F or higher; consider intervention measures

3.1.2 Rebuilding Shasta Storage

The closer Shasta Reservoir is to full by the end of May, the greater the likelihood of being able to meet the winter-run Chinook salmon temperature targets throughout the entire temperature control season (May 15 to Oct 30). Reclamation proposed several operational components that are intended to increase spring Shasta Reservoir storage levels as compared to recent years. These include (1) fall and winter refill and redd maintenance, which sets minimum late fall and winter flows; (2) modified fall outflow requirements; (3) flexibility in water delivery operations (i.e., water withdrawn from the system to serve contracts) (especially in April and May); and (4) December 2018 changes to the Coordinated Operations Agreement. Reclamation expects that these operations, as well as real-time operations, will result in increased end of September carryover storage, which Reclamation expects to benefit the following May 1 storage in years without flood control releases.

3.1.3 Fall and Winter Refill and Redd Maintenance

Maintaining releases to keep late spawning winter-run Chinook salmon redds underwater may drawdown storage necessary for temperature management in a subsequent year. Reclamation proposes to balances these needs by reducing fall releases to 3,250 cfs to save cold water and storage for next year’s temperature management season in years with lower end-of-September storage. In years with sufficient end of September storage, Reclamation will maintain higher releases in the fall to avoid de-watering the last winter-run salmon redds. Reclamation will also adhere to ramping rate restrictions to reduce the risk of juvenile stranding during these operations.

3.1.4 Rice Decomposition Smoothing

In the same time period as the fall and winter redd maintenance above, upstream Sacramento Valley CVP contractors and the SRS Contractors propose to work to synchronize their diversions to lower peak rice decomposition demand. With lower late October and early November flows, fall-run Chinook salmon are less likely to spawn in shallow areas that would be subject to dewatering during winter base flows. Early flow reductions (late October to early November) are proposed to balance the potential for dewatering late spawning winter-run Chinook salmon redds and early fall-run Chinook salmon redds.

3.1.5 Spring Pulse Flows

In years with sufficient cold water pool (likely more than 4 million acre-feet in storage in Shasta Reservoir on May 1), Reclamation proposes to release one or more spring pulses of up to a total of 150 thousand acre-feet if the pulse does not interfere with the ability to meet performance objectives or other anticipated operations of the reservoir.

3.1.6 Intervention Actions (Drought Toolbox)

In severe drought (lower Tier 3 years and Tier 4 years), Reclamation proposes to ensure Sacramento River winter-run Chinook salmon survival by increasing production at the Livingston Stone National Fish Hatchery, trapping juvenile Chinook salmon and hauling them to the Delta, and avoiding uncontrollably hot temperatures in the Sacramento River. Reclamation would also trap adults that may be stranded behind flood weirs.

Reclamation also proposes to coordinate with NMFS, FWS, CDFW and DWR in developing a toolkit to address drought. Drought and dry year planning will include the measures under Shasta Cold Water Pool Management Dry Years, Drought Years, and successive Dry Years. Reclamation proposes to discuss intervention measures to address low storage conditions in Tier 4 years and in Tier 3 years if the Tier 3 year is forecast to be at the lower end of Tier 3 storage.

In addition, during drier water years with operational conditions that match Tier 3 and Tier 4 scenarios (see Section 3.1), Reclamation will meet and confer with FWS, NMFS, DWR, CDFW, and SRS Contractors on measures to be considered if drought conditions continue into the following year, including measures that may be beyond Reclamation and DWR’s discretion.

3.1.7 Habitat Restoration and Facility Improvements

In addition to the operational and drought intervention actions above, Reclamation proposes to provide grants to water users to screen small diversions, avoiding fish entrainment; add 15,000 to 40,000 tons of spawning gravel a year; create 40 to 60 acres of rearing habitat in the Sacramento River; and provide grants to water users near Wilkins Slough to allow operations at lower flows, helping conserve storage in Shasta Reservoir.

3.1.8 Battle Creek Reintroduction Plan

Reclamation commits to providing up to $14,500,000 over ten years to reintroduce of Winter-run Chinook salmon to Battle Creek. Reclamation will accelerate implementation of the Battle Creek Salmon and Steelhead Restoration Project, which is intended to reestablish approximately 42 miles of prime salmon and steelhead habitat on Battle Creek, and an additional six miles on its tributaries. The intent is to expand winter-run Chinook Salmon spawning beyond its current limited range in a single spawning population in the upper Sacramento River through fish passage construction and reintroduction of winter run Chinook.

3.1.9 Deer Creek Irrigation District Dam Fish Passage

Reclamation will provide up to $1,000,000 towards a collaborative project to construct fish passage downstream of the Deer Creek Irrigation District Dam to provide spring-run Chinook salmon and Central Valley steelhead with unimpeded access to 25 miles of prime spawning habitat. Improving fish passage at this site will improve upstream access to spawning, rearing and holding habitat.

3.1.10 Knights Landing Outfall Gates

Reclamation will provide up to $700,000 toward reconstruction of the Knights Landing Outfall Gates to reduce the potential for fish straying into and getting trapped in the Colusa Basin Drain.

3.1.11 Special Studies

Reclamation recognizes the need to continue to improve best available science and collaborative operational modeling tools. Reclamation will evaluate the Shasta temperature control device performance and explore solutions; coordinate with NMFS to establish experiments to refine the state of the science and determine if keeping water colder earlier induces earlier spawning, and will support other research.

3.1.12 Collaborative Planning and Ongoing Scientific Review

Reclamation clarified that it will implement actions through collaborative planning to continue to identify and implement actions that benefit listed species through the Collaborative Science Adaptive Management Program, Interagency Ecological Program, Delta Plan Interagency Implementation Committee and CVPIA planning groups. Reclamation also added a commitment to review the implementation of the proposed action at four year intervals (i.e., 4-year and 8-year reviews) through an independent panel of experts to review the Upper Sacramento River Performance Metrics.

3.2 Trinity River Division Operations

Diversion of Trinity Basin water to the Sacramento Basin (trans-basin diversion) provides water supply and major hydroelectric power generation for the CVP and plays a key role in water temperature control in the Trinity River and upper Sacramento River. Trans-basin diversions would be managed to support water supply and temperature objectives within the Sacramento system. Trinity River exports are first conveyed through Carr Power Plant which flows directly into Whiskeytown Lake. From Whiskeytown Lake, the exported water continues to flow into Spring Creek Power Plant, is discharged into Keswick Reservoir where it mixes with water from Shasta, and then outflows into the Sacramento River, or water is released from Whiskeytown to Clear Creek. Two temperature curtains in Whiskeytown Reservoir were 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.

Runoff containing acid mine drainage from several inactive copper mines and exposed ore bodies at Iron Mountain Mine is stored in Spring Creek Reservoir. DWR operates Oroville Dam consistent with the NMFS, FWS, and CDFW environmental requirements applicable for the current FERC License for flood control, to meet Sacramento–San Joaquin Delta requirements, and deliver water supplies to its contracted water agencies consistent with all environmental constraints.

Proposed Action Components

Reclamation proposes the following specific actions in addition to current ongoing operations.

3.2.1 Whiskeytown Reservoir Operations

Reclamation proposes to operate 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.

3.2.2 Clear Creek

Reclamation proposes to release Clear Creek flows in accordance with the 1960 Memorandum of Agreement with CDFW, and the April 15, 2002 State Water Resource Control Board permit, which established minimum flows to be released to Clear Creek at Whiskeytown Dam. Reclamation proposes a minimum base flow in Clear Creek of 200 cfs from October through May and 150 cfs from June to September in all year types except Critical year types.

Reclamation proposes to create pulse flows for both channel maintenance and spring attraction flows. For spring attraction flows, Reclamation would release 10 thousand acre-feet from Whiskeytown Dam in all year-types except for Critical year-types. For channel maintenance flows, Reclamation would release 10 thousand acre-feet from Whiskeytown Dam, in all year-types except for Dry and Critical year-types.

Reclamation proposes 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 15 to October 31.

3.2.3 Spring Creek Debris Dam

Reclamation proposes to implement actions that will protect the Sacramento River system from heavy metal pollution (i.e., acid mine runoff) from Spring Creek Dam and adjacent watersheds including water quality criteria and criteria for protection of aquatic life in the upper Sacramento River.

3.3 American River Division Operations

Reclamation operates the American River Division for flood control, municipal and industrial, 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 capacity), 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. Folsom Reservoir is the largest storage and flood control reservoir on the American River.

Proposed Action Components

Reclamation proposes the following specific actions in addition to current ongoing operations.

3.3.1 Temperature Management

Reclamation proposes to manage the Folsom/Nimbus Dam complex and the water temperature control shutters at Folsom Dam to maintain 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 steelhead rearing in the lower American River, as long as cold water is available.

3.3.2 Spring Pulse Flow

The proposed action includes a spring pulse flow event under certain conditions when the water has been made available from non-CVP sources or no such flow event has occurred already in the spring. This spring pulse flow provides a juvenile salmonid emigration cue before relatively low water flow and associated unsuitable thermal conditions later in the spring, and downstream in the lower Sacramento River.

3.3.3 Habitat Restoration and Facility Improvements

Reclamation has proposed to continue spawning and rearing habitat restoration actions to improve juvenile productivity, as well as to evaluate and implement alternative shutter configurations at Folsom Dam to allow temperature flexibility in severe drought years.

3.3.4 Special Studies

Reclamation recognizes the need for genetically diverse hatchery populations to maintain resilient populations. Therefore, Reclamation will complete Hatchery and Genetics Management Plans (HGMPs) for Central Valley Steelhead and Fall-run Chinook Salmon for use in Nimbus Fish Hatchery management.

3.4 Bay-Delta Division Operations

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 gates, 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, Clifton Court Forebay, Skinner Delta Fish Protective Facility, and Barker Slough Pumping Plant.

Winter and spring pumping operations generally target exports of excess, unregulated, and unstored water to help meet project demands later in the season while meeting Delta water quality and flow criteria. Delta operations during the summer are typically focused on maintaining salinity and meeting Delta outflow objectives while maximizing exports with the available water supply. Fall Delta operations typically begin as demands decrease, accretions increase within the system, and reservoir releases are decreasing to start conserving water. Fall pumping typically targets exports of available excess water in the system and may decrease if the fall remains dry.

The Delta cross channel is a controlled diversion channel between the Sacramento River and Snodgrass Slough. When Delta cross channel gates are open, water is diverted from the

Sacramento River through a short excavated channel into Snodgrass Slough and then flows through natural channels for about 50 miles to the vicinity of Banks and Jones Pumping Plants.

Proposed Action Components

Reclamation proposes the following specific actions in addition to current ongoing operations.

3.4.1 Delta Cross Channel

Reclamation proposes to operate the Delta cross channel in the open position to (1) improve the efficiency of conveying water from the Sacramento River to the export facilities at the Banks and Jones Pumping Plants; (2) improve water quality in the central and southern Delta; and (3) reduce salinity intrusion rates in the western Delta. During the late fall, winter, and spring, the gates would be periodically closed to protect out-migrating salmonids from entering the interior Delta and to facilitate meeting the D-1641 Rio Vista flow objectives for fish passage. In addition, whenever flows in the Sacramento River at Sacramento reach 20,000 to 25,000 cfs, the gates would be closed to reduce potential scouring and flooding that might occur in the channels on the downstream side of the gates.

Reclamation proposes to operate the Delta cross channel gates to reduce juvenile salmonid entrainment risk beyond actions described in D-1641, consistent with Delta water quality requirements in D-1641. From October 1 to November 30 Reclamation proposes to operate the Delta cross channel gates in the open position unless monitoring indicates a higher risk of fish presence, in which case the gates will close. From December 1 to January 31, the Delta cross channel gates will be closed, except to prevent exceeding a D-1641 water quality threshold. During a Delta cross channel gates opening between December 1 and January 31, the CVP and SWP will divert at Health and Safety pumping levels.

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 will perform a risk assessment to determine the timing and duration of the gate closure.

3.4.2 Delta Cross Channel Drought Coordination

If in drought conditions, Reclamation and DWR propose to coordinate with FWS, NMFS, and State Water Resource Control Board on how to balance water quality and listed fish requirements. During a Delta cross channel gates opening between December 1 and January 31, the CVP and SWP will divert at health and safety pumping levels.

3.4.3 Agricultural Barriers

Reclamation and DWR propose to continue to construct and operate three temporary rock barriers in the Delta to allow Delta farmers to withdraw water.

3.4.4 Old and Middle River Reverse Flow Management

Reclamation proposes to minimize the extent of negative flows in Old and Middle River that lead to the pumping plants. Reclamation and DWR propose to operate Old and Middle Rivers to no more negative than -5000 cfs during the Old and Middle Rivers management season (roughly January through June, depending on fish presence). The proposed action uses updated modeling tools and real-time monitoring to determine when to reduce pumping for Delta smelt, including during high turbidity events in the winter and when modeling shows larval smelt could be entrained into the pumping plants. Reclamation and DWR also propose to limit pumping when single-year or cumulative loss thresholds are reached. Old and Middle Rivers flows more negative than -5000 cfs are allowed during storm events. Under the following conditions, Reclamation and DWR would not cause Old and Middle Rivers to be more negative for capturing peak flows from storm-related events if:

- Integrated early winter pulse protection (above) or additional real-time Old and Middle Rivers restrictions (above) are triggered. Under such conditions, Reclamation and DWR propose to implement more restrictive Old and Middle Rivers operations.
- An evaluation of environmental and biological conditions indicates more negative Old and Middle Rivers would likely cause Reclamation and DWR to trigger an additional real-time Old and Middle Rivers restriction (above).
- Salvage of yearling Coleman National Fish Hatchery late fall-run as yearling spring-run Chinook salmon surrogates exceeds 0.5 percent within any of the release groups.
- Reclamation and DWR identify changes in spawning, rearing, foraging, sheltering, or migration behavior beyond those described in this opinion.

Old and Middle Rivers restrictions for fish are proposed to overrule any storm-related Old and Middle Rivers flexibility.

3.4.5 Old and Middle Rivers single-year and cumulative loss thresholds

Reclamation proposes to adopt single year and cumulative loss thresholds for salmonids consistent with loss observed over the timeframe of the 2009 Biological Opinion (National Marine Fisheries Service 2009b). Reclamation committed to a cumulative loss threshold based on cumulative historic loss from 2010-2018, and a single-year loss threshold that is no greater than 90 percent of the highest annual loss that occurred from 2010-2018. If 50 percent of a single-year threshold is exceeded Old and Middle Rivers will be reduced to a 14-day moving average of -3,500 cfs unless a risk assessment, based on real-time fish monitoring data finds that the risk is no longer present. If 75 percent of the threshold is exceeded, Old and Middle Rivers will be reduced to -2,500 cfs, for the remainder of the Old and Middle Rivers season unless a risk assessment, based on real-time fish monitoring data finds that the risk is no longer present.

3.4.6 Old and Middle Rivers Performance Metrics

If, at any time prior to 2024, loss at the export facilities exceeds 50 percent of the cumulative loss threshold, Reclamation and DWR will convene and independent panel to review the actions contributing to the loss trajectory and make recommendations on modifications or additional actions to stay within the cumulative loss threshold. Similar to the cumulative loss objectives, if the single-year loss threshold is exceeded, an independent panel will be convened to evaluate the efficacy of the actions taken to reduce effects to listed fish species and will provide recommendations for actions to reduce effects in following years. Regardless of the trajectory, in the year 2024, Reclamation and DWR will convene the independent panel to review the past five years of the action and determine whether continuing actions will reliably maintain the trajectory for the duration of the consultation period.

3.4.7 Summer-Fall Delta Smelt Habitat

An experiment in 2018 showed infrastructure in the Delta can assist in creating habitat for Delta Smelt. Reclamation and DWR propose to operate the Suisun Marsh Salinity Control Gates in the summer and fall to create habitat for Delta Smelt in Suisun Marsh, in combination with a variety of actions to generate food from the Colusa Basin Drain, Roaring River Distribution System, and Sacramento Deepwater Ship Channel. In addition, in years where the new operation of the infrastructure is unable to create sufficient habitat, Reclamation and DWR would operate to create a two parts per thousand salinity isohaline at 80 kilometers from the Golden Gate Bridge. This location is key for possible low salinity habitat in Suisun Marsh.

Reclamation further improved the Delta Smelt Habitat Action by modifying the action to operate to a monthly average X2 of 50 miles (80 kilometers) in September and October in above normal and wet years as an operational back-stop to provide a specific acreage of low salinity habitat. Reclamation and DWR clarified the process of working with agencies and stakeholders throughout the year to implement this action.

3.4.8 Water Transfers

Reclamation proposes to expand the water transfer window to July through November, which can provide additional flexibility in meeting water temperature requirements in drought years. Maximum water transfer volumes remain the same as under current operations. Water transfers include north to south transfers.

3.4.9 Other Delta Facilities

Reclamation proposes to continue current operations of other Delta facilities including Rock Slough, Suisun Marsh Preservation Agreement facilities, Tracy and Skinner Delta Fish Protective Facility operations, and the North Bay Aqueduct. Reclamation is only consulting on new aspects of Suisun Marsh facility operations

3.4.10 Habitat Restoration and Facility Improvements

In addition to preventing entrainment and creating habitat through the actions above, Reclamation and DWR propose continuing to improve fish salvage efficiency at Tracy and Skinner Delta Fish Protective Facility and release sites; reduce mortality of listed fish in Clifton Court Forebay; evaluate improvements to the Delta Cross Channel gate; complete the remaining approximately 6,000 acres of tidal habitat restoration in the Delta that DWR has begun; complete the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project to greatly increase floodplain habitat acreage; screen small diversions; and remove predator hot spots.

3.4.11 Special Studies

Reclamation proposes to conduct a San Joaquin Basin Steelhead Telemetry Study, which would be a continuation of the six-year steelhead telemetry study for the migration and survival of San Joaquin River origin CCV steelhead. Reclamation also proposes to develop and implement a sediment supplementation feasibility study in the Delta to provide better habitat conditions for delta smelt.

3.4.12 Steelhead Lifecycle Monitoring Program

Reclamation and DWR propose to develop a steelhead lifecycle monitoring program in the Stanislaus River and a Sacramento basin CVP tributary (e.g., Clear Creek, Upper Sacramento, American River) to evaluate how actions related to stream flow enhancement, habitat restoration, and/or water export restrictions affect biological outcomes including population abundance, age structure, growth and smoltification rates, and anadromy and adaptive potential in these two populations.

3.4.13 Collaborative Planning and Ongoing Scientific Review

Reclamation clarified that it will implement actions through collaborative planning to continue to identify and implement actions that benefit listed species through the Collaborative Science Adaptive Management Program, Interagency Ecological Program, Delta Plan Interagency Implementation Committee and CVPIA planning groups. Reclamation also added a commitment to review the implementation of Old and Middle River management and measures to improve survival through the south Delta and Delta Smelt Summer-Fall Habitat Actions.

3.5 Stanislaus River (East Side Division)

Reclamation operates the CVP East Side Division for flood control, agricultural water supplies, hydroelectric power generation, fish and wildlife protection, and recreation. The New Melones Dam operates in conjunction with Tulloch Reservoir and Goodwin Dam on the Stanislaus River. Goodwin Dam, completed in 1912, is an impassible barrier to upstream fish migration at river mile 59. Water is released from New Melones to satisfy senior water right entitlements, instream and Vernalis salinity standards specified under D-1641 and D-1422, CDFG fish agreement flows, CVP water contracts and b(2) or CVPIA 3406(b)(3).

Proposed Action Components

Reclamation proposes the following specific actions in addition to current ongoing operations.

3.5.1 Minimum Flows

Reclamation proposes to operate New Melones Reservoir to provide minimum releases at Goodwin Dam according to a Stepped Release Plan with annual release volumes by year type as shown in Table 5. The daily flow schedules (one for each water year type) of the proposed stepped release plan are provided in Appendix F of this Opinion. When compared to minimum daily flow schedules from Appendix 2-E of the NMFS 2009 Opinion, the minimum daily flow schedules for the New Melones stepped release plan are identical for critical, dry, and below normal year types; above normal and wet year types follow minimum daily flow schedules for below normal and above normal year types from Appendix 2-E of the NMFS 2009 Opinion, respectively (Table 5). Notably, Reclamation also proposes 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 currently.

Table 5. New Melones Stepped Release Plan annual releases by year type based on San Joaquin Valley "60-20-20" Index.

Water Year Type (60-20-20 Index)	Stepped Release Plan Annual Release (thousand acre-feet)	Equivalent to Appendix 2-E schedule from listed year type (New Melones Index)
Critical	184.3	Critical
Dry	233.3	Dry
Below normal	344.6	Below normal
Above normal	344.6	Below normal
Wet	476.3	Above normal

Source: ROC on LTO biological assessment: Modification of Table 4-14

Reclamation proposes to implement the stepped release plan similar to current operations, in that seasonal flow volumes (as defined in the default daily flow schedules) may be shaped to meet specific biological objectives. The Stanislaus Watershed Team (successor to the Stanislaus Operations Group), which will include stakeholders (unlike the Stanislaus Operations Group, which includes only agency members) will provide input on shaping seasonal flows.

3.5.2 Habitat Restoration

Reclamation proposes to construct an additional 50 acres of rearing habitat adjacent to the Stanislaus River by 2030.

3.5.3 Gravel Augmentation

Under the CVPIA (b)(13) program, Reclamation's annual goal of gravel placement is approximately 4,500 tons in the Stanislaus River.

3.6 San Joaquin River

Reclamation operates the Friant Division for flood control, irrigation, municipal and industrial, and fish and wildlife purposes. Facilities include Friant Dam, Millerton Reservoir, and the Friant-Kern and Madera Canals. The SJRRP implements the San Joaquin River Restoration Settlement Act in Title X of Public Law 111-11. FWS and NMFS issued programmatic biological opinions in 2012 that included project-level consultation for SJRRP flow releases. Programmatic ESA coverage is provided for flow releases up to a certain level, recapture of those flows in the Lower San Joaquin River and the Delta, and all physical restoration and water management actions listed in the Settlement. Therefore, the operation of Friant Division facilities was not included in this consultation. Conservation measures for San Joaquin River rearing habitat were not part of the 2012 opinion were included in Reclamation's proposed CVP and SWP action and are described below.

Proposed Action Components

Reclamation proposes the following specific actions in addition to current ongoing operations.

3.6.1 San Joaquin River Scour Hole

Reclamation and DWR propose to plan and implement measures to reduce the predation intensity at the San Joaquin River Scour Hole through modifications to the channel geometry and associated habitats.

3.6.2 San Joaquin Basin Steelhead Collaborative

Reclamation proposes to coordinate with CSAMP to sponsor a workshop for developing a plan to monitor steelhead populations within the San Joaquin Basin and/or the San Joaquin River downstream of the confluence of the Stanislaus River, including steelhead and rainbow trout on non-project San Joaquin tributaries.

3.6.3 Roaring River Distribution System Dissolved Oxygen Monitoring

Reclamation and DWR propose to monitor for dissolved oxygen in Grizzly Bay when operating the Roaring River Distribution System for food subsidies. This monitoring would be intended to make sure the action does not cause hypoxia in fish.

4 Interrelated or Interdependent Actions

"Interrelated actions" are those that are part of a larger action and depend on the larger action for their justification. "Interdependent actions" are those that have no independent utility apart from the action under consideration (50 CFR 402.02). The proposed action encompasses a broad-scale program of activities. Any effects were captured within the analysis of the effects of the proposed action.

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 was (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) 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 coastal areas in California, Oregon, and Washington, where there is co-occurrence of Central Valley Chinook salmon and SRKWs. The action area also includes Battle Creek, Deer Creek, and Spring Creek Reservoir, Debris Dam and Spring Creek, where restoration and water quality actions are proposed.

6 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 physical and biological features that form the value for the conservation of the species. The designations of critical habitat for CV spring-run Chinook salmon, CCV steelhead and green sturgeon use the term primary constituent elements or essential features. The new critical habitat regulations (81 FR 7414) replace this term with physical or biological features. This shift in terminology does not change the approach used in conducting our analysis, whether the original designation identified primary constituent elements, physical or biological features, or essential features.

6.1 Sacramento River Winter-run Chinook Salmon

- First listed as threatened August 4, 1989 (54 FR 32085)
- Reclassified as endangered ((59 FR 440); January 4, 1994); reaffirmed as endangered ((70 FR 37160); June 28, 2005); reaffirmed as endangered ((81 FR 33468); May 26, 2016)
- Designated critical habitat ((58 FR 33212); June 16, 1993)

The federally listed ESU of Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*) and designated critical habitat occurs in the action area and may be affected by the proposed action.

Sacramento River winter-run Chinook salmon are particularly important among California's salmon runs because they exhibit a life-history strategy found nowhere else in the world. These Chinook salmon are unique because they spawn during the summer months when air temperatures usually approach their warmest. As a result, winter-run Chinook salmon require stream reaches with cold-water sources to protect their incubating eggs from the warm ambient conditions.

Historically, winter-run Chinook salmon population estimates were as high as 120,000 fish in the 1960s, but declined to less than 200 fish by the 1990s (National Marine Fisheries Service 2011c). In recent years, since carcass surveys began in 2001, the highest adult escapement occurred in 2005 and 2006 with 15,839 and 17,296, respectively (California Department of Fish and Wildlife 2016b). From 2007 to 2017, the population has shown a precipitous decline, averaging 2,733 during this period, with a low of 827 adults in 2011 (California Department of Fish and Wildlife 2018b). This recent declining trend is likely due to a combination of factors such as poor ocean productivity (Lindley et al. 2009), drought conditions from 2007 to 2009, low in-river survival (National Marine Fisheries Service 2011c), and extreme drought conditions in 2012 to 2016 (National Marine Fisheries Service 2016c). In 2015, the population was 3,015 adults, slightly above the 2007 to 2012 average, but below the high (17,296) for the last 10 years (California

Department of Fish and Wildlife 2016b). While 2018 adult returns were also relatively low (2,639, (California Department of Fish and Wildlife 2019a)) escapement in 2019 appears to have risen above these recent lows, as the most recent preliminary estimates from September of 2019 (~8,000 individuals) are more than double the number of adults reported for 2015 (Killam 2019b). Data from recent years also appear to indicate juvenile production since 2015 has been increasing; passage estimates of unclipped winter-run Chinook salmon juvenile outmigrants based on rotary trap observations at Red Bluff Diversion Dam were over three times higher in 2018 (1,168,270) than in 2015 (338,904), and preliminary data from 2019 had already exceeded the 2018 year total estimates by the end of September (U. S. Fish and Wildlife Service 2019)[4].

Assessing the temporal occurrence of each life stage is done through monitoring data in the Sacramento River and Delta as well as salvage data from the Tracy and Skinner fish collection facilities in the south Delta (CVP and SWP). Table 6 and Table 7 show the temporal occurrence of adult and juvenile Sacramento River winter-run Chinook salmon at locations in the action area.

[4] Although we acknowledge any preliminary data from 2019 are subject to change as a result of QA/QC that has not yet been performed, NMFS assumes these values are very consistent with the forthcoming finalized estimates from California Department of Fish and Wildlife or U.S. Department of Fish and Wildlife, as has been the case in previous years.

Table 6. Temporal occurrence of Sacramento River winter-run Chinook salmon by life-stage in the Sacramento River.

Relative Abundance	High (▼)			Medium (☒)			Low (#)			None (-)		
Adults Freshwater	Month											
Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sacramento River basin [a,b]	☒	☒	☒	☒	☒	☒	☒	-	-	-	☒	☒
Upper Sacramento River spawning [c]	-	-	-	-	#	▼	▼	☒	-	-	-	-
Juvenile Emigration	Month											
Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sacramento River at Red Bluff [d]	#	#	#	-	-	-	#	☒	☒	☒	☒	☒
Sacramento River at Knights Landing [e]	▼	☒	#	-	-	-	-	-	-	#	☒	▼
Sacramento trawl at Sherwood Harbor [f]	☒	▼	▼	#	-	-	-	-	-	-	☒	▼
Midwater trawl at Chipps Island [f]	☒	☒	▼	▼	#	-	-	-	-	-	-	#

Sources: [a] Yoshiyama et al. (1998), Moyle (2002) ; [b]Myers et al. (1998); [c]Williams (2006); [d]Martin et al. (2001); [e]Knights Landing Rotary Screw Trap Data, CDFW (1999-2019); [f] Delta Juvenile Fish Monitoring Program, USFWS (1995-2019), del Rosario et al. (2013).

Table 7. Temporal occurrence of Sacramento River winter-run Chinook salmon by life-stage in the Delta.

Relative Abundance	High (▼)	Medium (☒)	Low (#)	None (-)

Life-Stage	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult [1]	☒	▼	▼	▼	☒	☒	-	-	-	-	☒	☒
Juvenile [2]	#	☒	▼	☒	-	-	-	-	-	#	#	☒
Salvaged [3]	☒	▼	▼	#	#	#	-	-	-	-	-	#

[1] *Adults enter the Bay November to June (Hallock and Fisher 1985) and are in spawning ground at a peak time of June to July (Vogel and Marine 1991).*
[2] *Juvenile presence in the Delta was determined using Delta Juvenile Fish Monitoring Program data.*
[3] *Months in which salvage of wild juvenile winter-run at State and Federal pumping plants occurred (National Marine Fisheries Service 2016c).*

The year 2014 was the third year of a drought that resulted in increased water temperatures in the upper Sacramento River, and egg-to-fry survival to the Red Bluff Diversion Dam was approximately four percent ((National Marine Fisheries Service 2016c), Table 8). Due to the anticipated lower than average survival in 2014, hatchery production from Livingston Stone National Fish Hatchery was tripled (i.e., 612,056 released) to offset the impact of the drought (CVP and SWP Drought Contingency Plan 2014). In 2014, hatchery production represented 83 percent of the total in-river juvenile production. In 2015, egg-to-fry survival was the lowest on record (approximately three percent, Table 8) due to the inability to release cold water from Shasta Dam in the fourth year of the drought. Winter-run Chinook salmon returns in 2016 to 2018 were low, as expected, due at least in part to poor in-river conditions for juveniles from brood year 2013 to 2015 during drought years. The 2018 adult winter-run return (2,639) improved from 2017 (977) (California Department of Fish and Wildlife 2019a), though was similarly dominated by hatchery-origin fish.

Table 8. Sacramento River winter-run Chinook salmon egg-to-fry survival to the Red Bluff rotary screw traps.

Year	Egg-to-Fry Survival	Year	Egg-to-Fry Survival
2002	46%	2011	39%
2003	26%	2012	20%
2004	21%	2013	13%
2005	25%	2014	4%
2006	18%	2015	3%
2007	24%	2016	24%
2008	14%	2017	44%
2009	46%	2018	26%
2010	32%	2019	~29%[a]

[a]Data from 2019 were not complete at the time of writing this opinion, however, preliminary estimates for 2019 were provided by the NMFS SWFSC (National Marine Fisheries Service 2019c).

Although impacts from hatchery fish (i.e., reduced fitness, weaker genetics, smaller size, less ability to avoid predators) are often cited as having deleterious impacts on natural in-river populations (Matala et al. 2012), the winter-run Chinook salmon conservation program at Livingston Stone National Fish Hatchery is strictly controlled by the FWS to reduce such impacts. The average annual hatchery production at Livingston Stone National Fish Hatchery is approximately 216,015 per year (2001 to 2018 average) compared to the estimated natural production that passes Red Bluff Diversion Dam, which is 2.9 million per year based on the 2002 to 2018 average (Poytress and Carrillo 2011; U.S. Fish and Wildlife Service 2018a). Therefore, hatchery production typically represents approximately seven percent of the total in-river juvenile production in any given year. This percentage of hatchery origin emigrants results in a higher percentage of hatchery-origin spawners, with an average of 21 percent hatchery-origin spawners over the last 18 years (about six generations), putting the population at a moderate risk of extinction (National Marine Fisheries Service 2016c).

The distribution of winter-run Chinook salmon spawning and initial rearing historically included the upper Sacramento River (upstream of Shasta Dam), McCloud River, Pitt River, and Battle Creek, where springs provided cold water throughout the summer, allowing for spawning, egg incubation, and rearing during the mid-summer period (Yoshiyama et al. 1998). The construction of Shasta Dam in 1943 blocked access to all these waters except Battle Creek, which also had its own impediments to upstream migration (i.e., a number of small hydroelectric dams situated upstream of the Coleman National Fish Hatchery weir). The fish from these populations above Shasta Dam were forced to mix and spawn as one population downstream of Keswick Dam on the Sacramento River. The single population of winter run Chinook salmon has been supported by coldwater management operations at Shasta Dam. Construction and operation of hydropower facilities in Battle Creek made the creek inhospitable to winter-run Chinook salmon, which resulted in extirpation of the population from that area. As of 2019, implementation of the Battle Creek Salmon and Steelhead Restoration Project has completed construction of phase 1 (of 2), which included removal of one fish passage barrier (dam), and construction of NMFS-approved fish screens and ladders at the two remaining dams on North Fork Battle Creek. Phase 2 of the project has completed planning, and is currently in design phase. Additionally, beginning in 2018, winter-run Chinook salmon juveniles produced at Livingston Stone National Fish Hatchery have been released into North Fork Battle Creek in an effort to jump-start the reintroduction efforts described in the plan (ICF International 2016; U.S. Fish and Wildlife Service 2018b).

Approximately 299 miles of former tributary spawning habitat above Shasta Dam is inaccessible to winter-run Chinook salmon. Yoshiyama et al. (2001) estimated that in 1938, the upper Sacramento River had a “potential spawning capacity” of approximately 14,000 redds equal to 28,000 spawners. Since 2001, the majority of winter-run Chinook salmon redds have occurred in the first 10 miles downstream of Keswick Dam. Most components of the winter-run Chinook salmon life history (e.g., spawning, incubation, freshwater rearing) have been compromised by the construction of Shasta Dam (National Marine Fisheries Service 2014a).

The greatest risk factor for winter-run Chinook salmon lies within its spatial structure (National Marine Fisheries Service 2011c). The winter-run Chinook salmon ESU comprises only one population that spawns below Keswick Dam. The remnant and remaining population cannot access 95 percent of their historical spawning habitat and must, therefore, be artificially maintained in the Sacramento River by spawning gravel augmentation, hatchery supplementation, and regulation of the finite cold water pool behind Shasta Dam to reduce water temperatures.

This species is particularly vulnerable to environmental pressures such as the 2012 to 2015 drought. This vulnerability manifested during the drought with nearly two consecutive year class failures due to an inability to provide cold water throughout the egg and fry life stages. Warm water releases from Shasta Reservoir in 2014 and 2015 contributed to estimates of 5.6 percent and 4.2 percent egg-to-fry survival rates respectively, to Red Bluff Diversion Dam. Under varying hydrologic conditions from 2002 to 2013, winter-run Chinook salmon egg-to-fry survival ranged from three to nearly ten times higher than in 2014 and 2015. Survival improved after the drought ended with estimated egg-to fry survival rates of 24 percent in 2016, 44 percent in 2017, 26 percent in 2018, and approximately 29 percent in 2019 (although 2019 data were preliminary and analyses not yet complete at the time of writing) (National Marine Fisheries Service 2019c).

Winter-run Chinook salmon require cold water temperatures in the summer that simulate their upper basin habitat, and they are more likely to be exposed to the impacts of drought in a lower basin environment. Battle Creek is currently the most feasible opportunity for the ESU to expand its spatial structure. The Central Valley Salmon and Steelhead Recovery Plan (National Marine Fisheries Service 2014b) includes criteria for recovering the winter-run Chinook salmon ESU, including re-establishing a population into historical habitats in Battle Creek as well as upstream of Shasta Dam (National Marine Fisheries Service 2014b). As mentioned above, in 2017 and 2018 action was taken to initiate the reintroduction of winter-run Chinook salmon to Battle Creek using the progeny of captive broodstock from Livingston Stone National Fish Hatchery (U.S. Fish and Wildlife Service 2018b). This decision to spawn captive broodstock and use their progeny to initiate reintroduction of Sacramento River winter-run Chinook salmon into historic spawning habitats of Battle Creek was called the winter Chinook salmon "Jumpstart" Project (U.S. Fish and Wildlife Service 2018b). In March and early April of 2018, progeny of the winter-run Chinook salmon captive broodstock were released into the North Fork Battle Creek. Currently, the plan is for this Jumpstart Project to continue until a "Transition Plan" is developed to merge the Jumpstart Project with the Reinitiation Plan (U.S. Fish and Wildlife Service 2018b).

Adult 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 (Table 7) 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. Winter-run Chinook salmon adults 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 main stem Sacramento River upstream of the Delta, including the Yolo Bypass when inundated.

For juvenile winter-run Chinook salmon, a review of fish monitoring data from 2000 to 2016 at the Chipps Island trawl and the Sacramento River trawl (Sherwood Harbor) showed very low numbers present from July through October (Barnard et al. 2015; Miller et al. 2017; Speegle et al. 2013; U.S. Fish and Wildlife Service 2019; University of Washington Columbia Basin Research 2019) (Figure 13 and Figure 14). Juvenile winter-run Chinook salmon occur in the Delta primarily from November through early May with a peak occurrence in March, using length-at-date criteria from trawl data in the Sacramento River near Sherwood Harbor (Barnard et al. 2015; Miller et al. 2017; Speegle et al. 2013) (Table 7). Length-at-date criteria apply a simplified approach for identifying Chinook salmon runs that was developed by the California Departement of Fish and Wildlife in 1989. Although imprecise, length-at-date criteria are used as the primary method of identifying and enumerating the take of winter-run juveniles throughout the Central Valley and is based on observations that the spawning seasons of the four Central Valley Chinook Salmon runs are somewhat segregated in time.

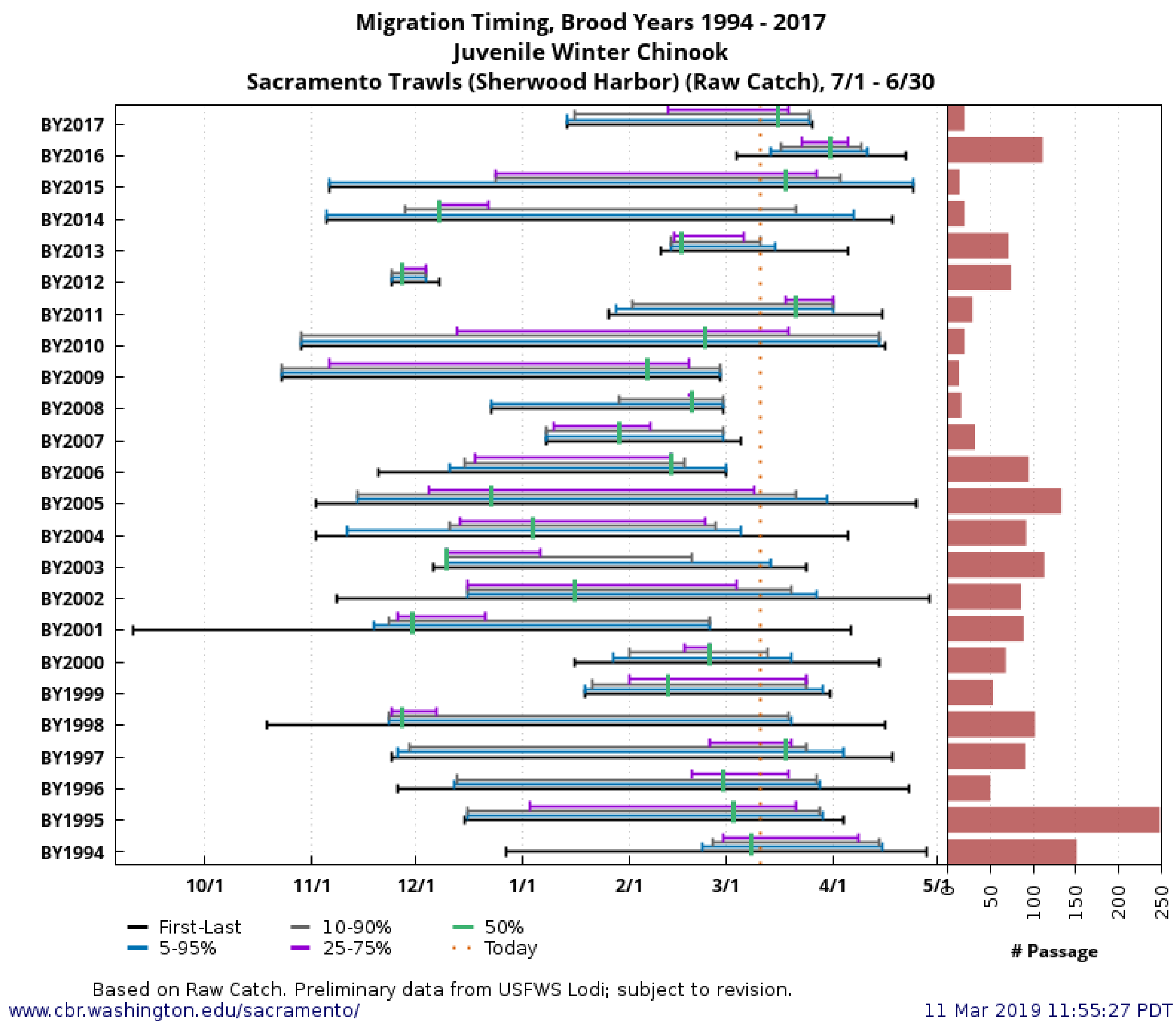


Figure 13. Juvenile Sacramento River winter-run Chinook salmon migration timing past the Sherwood Harbor - Sacramento Trawl location for brood years 1994 to 2017.

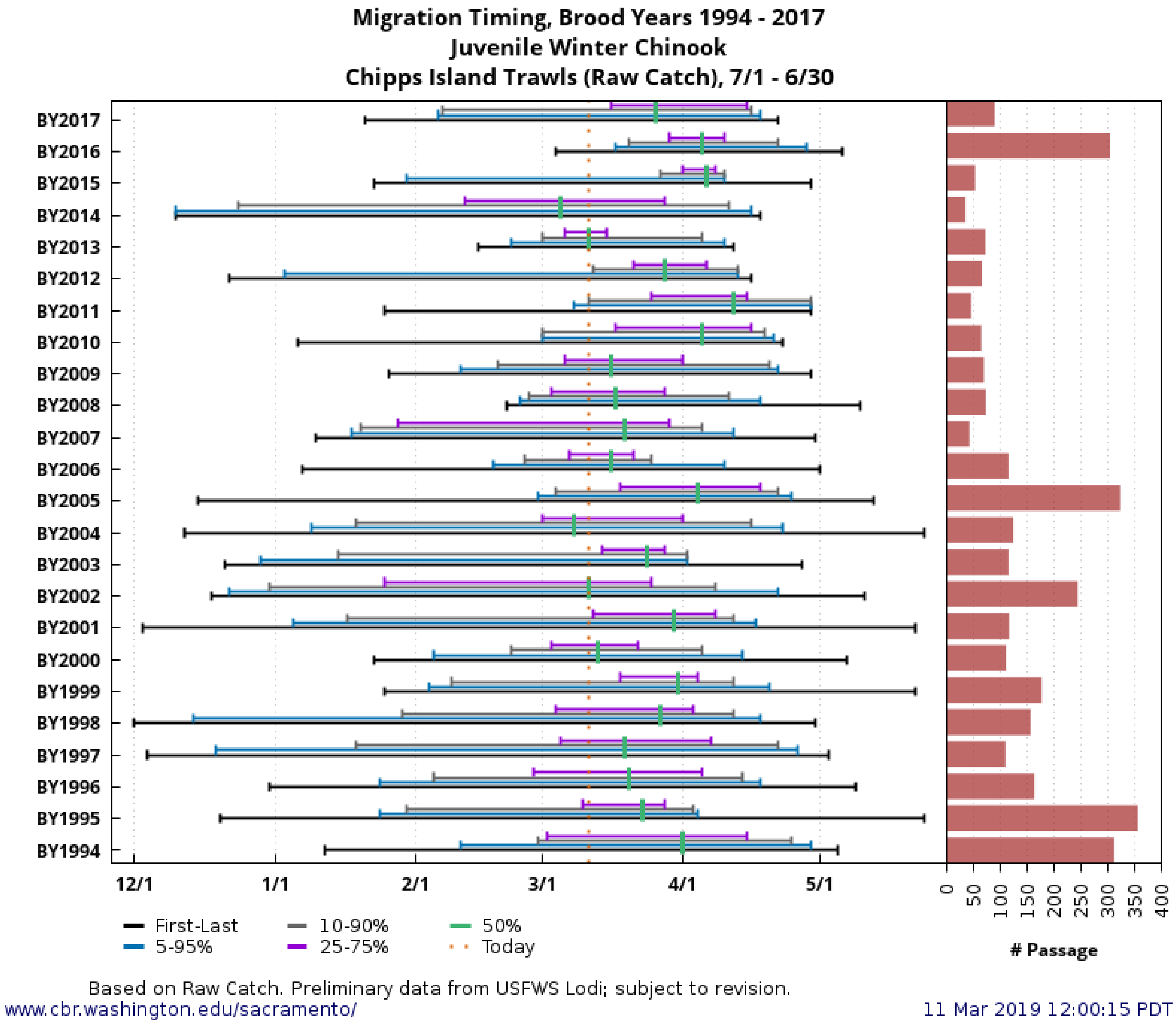


Figure 14. Juvenile Sacramentor River winter-run Chinook salmon migration timing past the Chipps Island trawl location for brood years 1994 to 2017.

Based on acoustic telemetry studies using late fall-run hatchery Chinook salmon (Perry et al. 2013; Perry et al. 2012; Perry et al. 2010; Romine et al. 2013), substantial fractions of the emigrating juvenile 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 as well as 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 that juvenile winter-run Chinook salmon are moving through alternate routes, they may utilize the Delta for rearing. A study by del Rosario et al. (2013) found that 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 Old and Middle rivers, as well as other channel junctions in this reach, rather than moving towards the western Delta. Juvenile 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 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 (Old and Middle rivers) leading to the export facilities due to the diversion of water at these facilities, juvenile winter-run 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 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 have shown that for Central Valley 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; Sturrock et al. 2015). 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 (Miller et al. 2010). A similar diversity of life history strategies may exist for winter-run Chinook salmon.

On occasion, the FWS has observed adult winter-run Chinook salmon and evidence of spawning in Clear Creek during monitoring since surveys began in 1999 (Killam and Mache 2018; Newton and Brown 2004). Video monitoring data at the mouth of Clear Creek has documented adults passing upstream, and although rare and intermittent, a few carcasses and redds have been reported over the years. Most recently, in July 2017, one redd was observed and three hatchery-tagged winter-run Chinook salmon carcasses were recovered (Clear Creek Technical Team 2019). Observations of winter-run Chinook salmon have only been made in the lower six miles of Clear Creek. While these observations have been made in Clear Creek we do not have sufficient information to determine to what extent actions in Clear Creek affecting these stray individuals would be expected to have an impact on the Sacramento River population. The recovery plan for this species also does not identify Clear Creek as a stream that would support a population of winter-run Chinook salmon. The effects of the proposed action in Clear Creek on Sacramento River winter-run Chinook salmon are therefore not analyzed further in this opinion.

There are no reported populations of 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 be stray into the channels of the Central Delta north of the main stem San Joaquin River as they try to regain access to the main stem Sacramento River through one of the major distributaries (i.e., Georgiana Slough and portions of the lower Mokelumne River system).

Winter-run Chinook salmon embryonic and larval life stages that are most vulnerable to warmer water temperatures occur during the summer, so this run is particularly at risk from climate warming. The only remaining population of 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 (Yates et al. 2008). The long-term projection of how the CVP and SWP will operate incorporates the effects of potential climate change in three possible forms: less total precipitation; a shift to more precipitation in the form of rain rather than snow; or earlier spring snow melt (U.S. Bureau of Reclamation 2008). Additionally, air temperature appears to be increasing at a greater rate than what was previously analyzed (Beechie et al. 2012; Dimacali 2013; Lindley 2008). These factors will compromise the quantity and/or quality of winter-run Chinook salmon habitat available downstream of Keswick Dam. The NMFS recovery plan identifies establishing redundant populations of winter-run Chinook salmon into historical habitat in Battle Creek and above Shasta Dam for long-term viability of the ESU (National Marine Fisheries Service 2014b).

Estimates of hatchery-origin winter-run Chinook salmon survival to age two are low relative to relevant benchmarks. For winter-run Chinook salmon, the mean smolt-to-adult ratio from 1999 to 2012 was 0.64 percent (standard error = 0.18), well below the Columbia River Basin Fish and Wildlife Program suggested minimum of two 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). Smolt-to-adult ratio should be treated as an index of survival that primarily represents survival from hatchery release to age two.

Lindley et al. (2007) developed extinction risk criteria for Central Valley salmonid populations based on viability parameters for abundance, population decline rate, and hatchery influence, and using data through 2004, found that the mainstem Sacramento River population was at low risk of extinction, but that the ESU as a whole remained at a high risk of extinction because there is only one naturally-spawning population, and it is not within its historical range. The overall extinction risk of winter-run Chinook salmon has increased since the 2007 and 2010 assessments (Williams et al. 2011; Williams et al. 2016). Based on the Lindley et al. (2007) criteria, the population is at high extinction risk in 2019. High extinction risk for the population was triggered by the hatchery influence criterion, with a mean of 66 percent hatchery origin spawners from 2016 through 2018. The threshold for high risk associated with hatchery influence is 50 percent hatchery origin spawners.

The recent increase in hatchery influence was expected as production from Livingston Stone National Fish Hatchery was increased during the drought to buffer against low adult returns resulting from poor survival of the 2014- and 2015-year class. This buffering appears to have been successful in the sense that adult escapement through 2018 met the low extinction risk criterion for abundance (i.e., census population size of 2,500).

In summary, there are several criteria that would qualify the winter-run Chinook salmon population at moderate risk of extinction (continued low abundance, a negative growth rate over two complete generations, significant rate of decline since 2006, increased hatchery influence on the population, and increased risk of catastrophe), and because there is still only one population that spawns below Keswick Dam, the winter-run Chinook salmon ESU is at high risk of extinction in the long term (Lindley et al. 2007). The extinction risk for the winter-run Chinook salmon ESU has increased from moderate risk to high risk of extinction since 2005, and several listing factors have contributed to the recent decline, including drought and poor ocean conditions (National Marine Fisheries Service 2016c).

6.2 Designated Critical Habitat for Sacramento River Winter-run Chinook Salmon

The critical habitat designation includes the following waterways, bottom and water of the waterways, and adjacent riparian zones: the Sacramento River from Keswick Dam (river mile 302) to Chipps Island (river mile 0) at the westward margin of the Delta; all waters from Chipps Island westward to the Carquinez Bridge, including Honker Bay, Grizzly Bay, Suisun Bay, and the Carquinez Strait; all waters of San Pablo Bay westward of the Carquinez Bridge; and all waters of San Francisco Bay north of the San Francisco-Oakland Bay Bridge from San Pablo Bay to the Golden Gate Bridge (58 FR 33212). NMFS clarified that "adjacent riparian zones" are limited to only those areas above a stream bank that provide cover and shade to the nearshore aquatic areas (58 FR 33212) (Figure 15). Although the bypasses (e.g., Yolo, Sutter, and Colusa) are not currently designated critical habitat for 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 winter-run. Also, juvenile winter-run Chinook salmon may use tributaries of the Sacramento River for non-natal rearing (Maslin et al. 1997; Pacific States Marine Fisheries Commission 2014; Phillis et al. 2018).

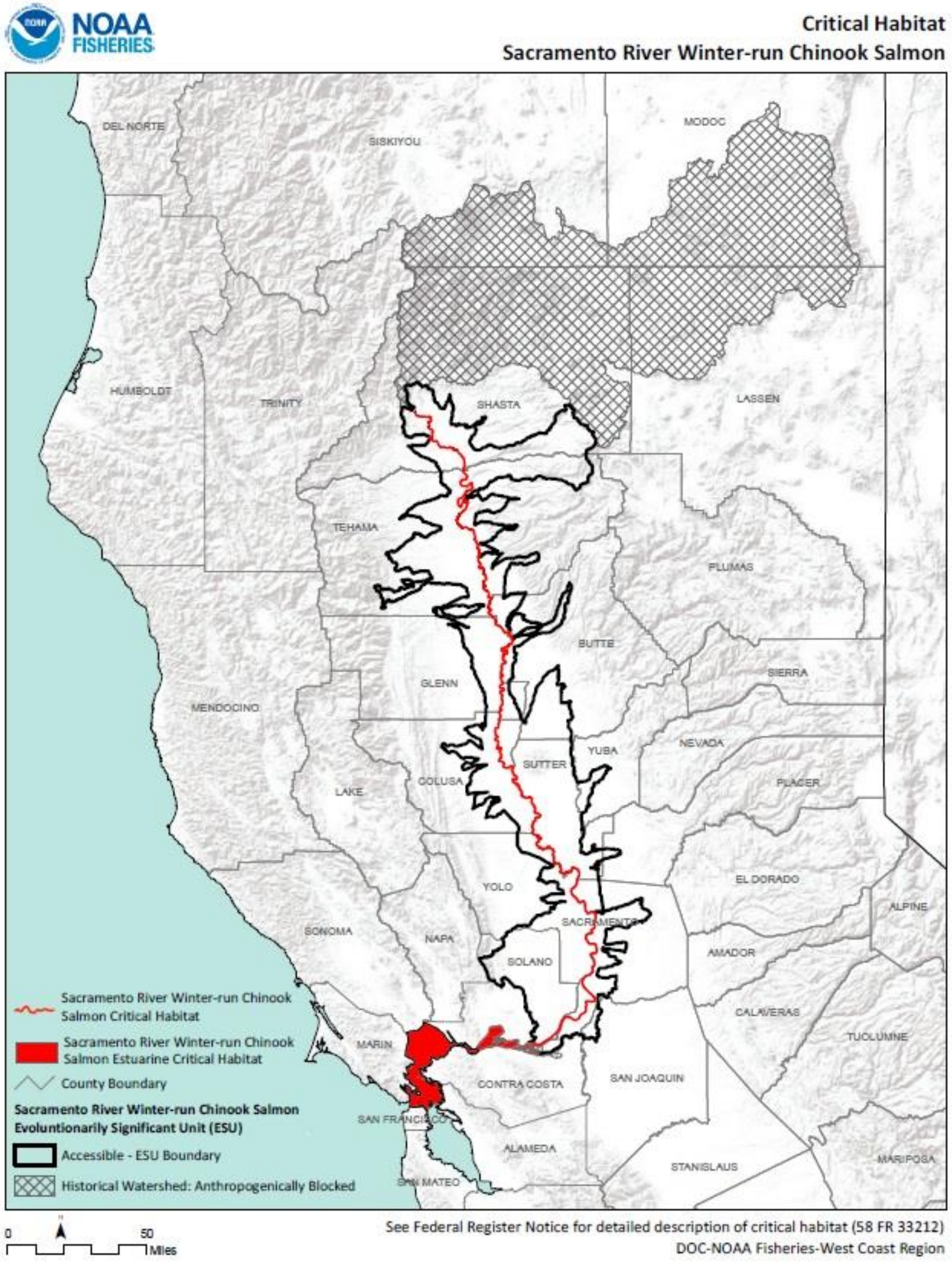


Figure 15. Winter-run Chinook salmon critical habitat in the Central Valley.

The proposed action area encompasses the entire range wide riverine and estuarine critical habitat physical and biological features for Sacramento River winter-run Chinook salmon. The critical habitat designation for winter-run Chinook salmon lists these features (58 FR 33212), which include:

(1) Access from the Pacific Ocean to appropriate spawning areas in the upper Sacramento River,

(2) The availability of clean gravel for spawning substrate,

(3) Adequate river flows for successful spawning, incubation of eggs, fry development and emergence, and downstream transport of juveniles,

(4) Water temperatures between 42.5 and 57.5°F for successful spawning, egg incubation, and fry development,

(5) Habitat 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 San Francisco Bay and the Pacific Ocean.

Widespread degradation to these physical and biological features has had a major contribution to the status of the winter-run Chinook salmon ESU, which is at high risk of extinction (National Marine Fisheries Service 2016c).

Currently, many of these physical and biological features are degraded and provide limited high quality habitat. Factors that lessen the quality of the migratory corridor for juveniles include unscreened diversions, altered flows in the Delta, Sacramento River and its tributaries, and the lack of floodplain habitat. In addition, Shasta Dam and water operations limit the extent of cold water, reduce the available spawning habitat, and degrade juvenile rearing and outmigration habitat (based on water temperature).

Passage impediments in the northern region of the Central Valley are largely responsible for isolating the existing population from historical spawning reaches, which occurred upstream of Keswick and Shasta dams and included the upper Sacramento River, McCloud River, Pit River, Fall River and Hat Creek (Lindley et al. 2004; National Marine Fisheries Service 2014a; Yoshiyama et al. 1996). Due to the installation of Keswick and Shasta dams, the winter-run ESU is now relegated to spawning downstream, in the Sacramento River. The majority of spawning occurs between Red Bluff Diversion Dam and Redding (below Keswick Dam) (National Marine Fisheries Service 2014a; Vogel and Marine 1991). Spatially, the total area of usable spawning habitat has been significantly diminished. Physical features that are essential to the functionality of existing spawning habitat have also been degraded such as: loss of spawning gravel, and elevated water temperatures during summer months when spawning events occur (National Marine Fisheries Service 2014a). Degradation of these features has been actively mitigated through real-time temperature and flow management at Shasta and Keswick dams (National Marine Fisheries Service 2009b) as well as gravel augmentation projects in the affected area, which have been occurring as described in a multi-year programmatic biological opinion (National Marine Fisheries Service 2016c).

Physical and biological features related to the rearing and migration of juveniles and adults have been degraded from their historical condition within the action area as well. Adult passage impediments on the Sacramento River existed for many years at the Red Bluff Diversion Dam and Anderson-Cottonwood Irrigation District diversion dam (National Marine Fisheries Service 2014a). The Red Bluff Diversion Dam was decommissioned in 2013, providing unimpaired juvenile and adult fish passage and a fish passage improvement project at the Anderson-Cottonwood Irrigation District was completed in 2015, so that adult winter-run Chinook salmon could migrate through the structure at a broader range of flows in order to reach spawning habitat upstream of that structure.

Juvenile migration corridors are impacted by reverse flows in the Delta that become exacerbated by water export operations at the CVP and SWP pumping plants. This results in impaired routing and timing for outmigrating juveniles and is evidenced by the presence of juvenile winter-run Chinook salmon at the State and Federal fish salvage facilities. Shoreline armoring and development has reduced the quality and quantity of floodplain habitat for rearing juveniles in the Delta and Sacramento River (Boughton and Pike 2013; Williams et al. 2009). Juveniles have access to floodplain habitat in the Yolo Bypass only during mid to high water years, 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 includes notching the Fremont Weir, which will provide access to floodplain habitat for juvenile salmon over a longer period (California Department of Water Resources and U.S. Bureau of Reclamation 2012). Although the critical habitat for winter-run Chinook salmon has been highly degraded, the importance of the reduced spawning habitat, migratory corridors, and rearing habitat that remains is of high value for the conservation of the species.

6.3 Central Valley Spring-run Chinook Salmon

- Listed as threatened ((64 FR 50394); September 16, 1999); reaffirmed as threatened 70 ((70 FR 37160); June 28, 2005)
- Designated critical habitat ((70 FR 52488); September 2, 2005)

The federally listed ESU of CV spring-run Chinook salmon and designated critical habitat occur in the action area and may be affected by the proposed action (Figure 16).

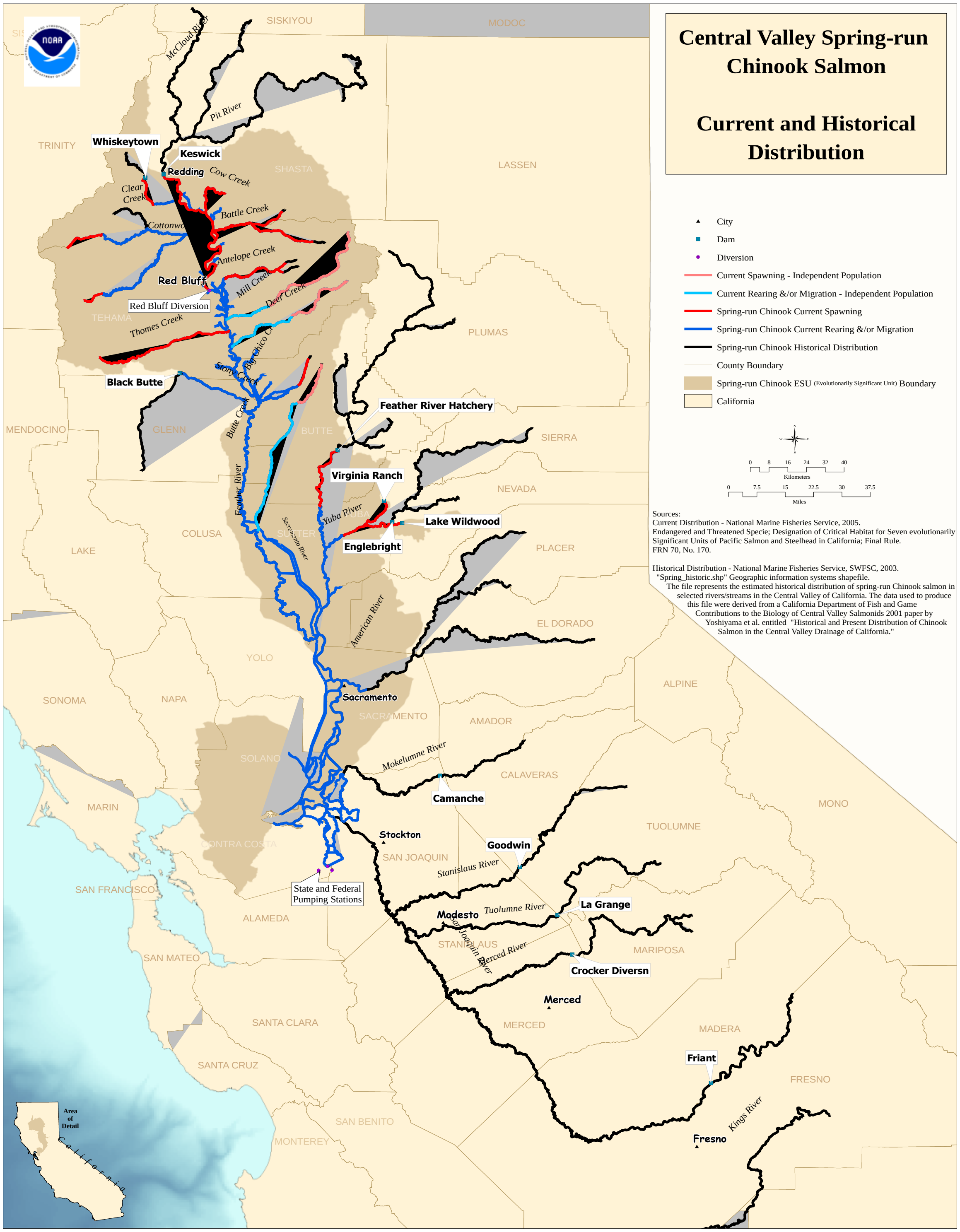


Figure 16. Current and historical distribution of the Central Valley spring-run Chinook salmon Evolutionarily Significant Unit.

Historically, spring-run Chinook salmon were the second most abundant salmon run in the Central Valley and one of the largest on the west coast (California Department of Fish and Game 1990). These fish occupied the upper and middle elevation reaches (1,000 to 6,000 feet) of the San Joaquin, American, Yuba, Feather, Sacramento, McCloud, and Pit rivers (Figure 16), with smaller populations in most tributaries with sufficient habitat for over-summering adults (Clark 1929; Rutter 1908; Stone 1872). The Central Valley drainage as a whole is estimated to have supported spring-run Chinook salmon runs as large as 600,000 fish between the late 1880s and 1940s (California Department of Fish and Game 1998). The San Joaquin River historically supported a large run of spring-run Chinook salmon, suggested to be one of the largest runs of any Chinook salmon on the West Coast with estimates averaging 200,000 to 500,000 adults returning annually (California Department of Fish and Game 1990). Currently, naturally-produced CV spring-run Chinook salmon are extirpated from the San Joaquin River due to habitat loss (National Marine Fisheries Service 2016a), as explained in more detail below.

Currently there are no documented non-experimental populations of CV spring-run Chinook salmon in the San Joaquin River. There is evidence of Chinook salmon occurring in the Stanislaus and Tuolumne rivers that may represent residual populations of spring-run Chinook salmon or individuals that have strayed from other river basins and use the Stanislaus and Tuolumne rivers for spawning based on their run timing and the presence of fry and juveniles that show traits characteristic of spring-run populations such as hatching dates and seasonal sizes (Franks 2013; National Marine Fisheries Service 2016a). These fish may represent strays from the Feather River hatchery (fall- or spring-run) or spring-run Chinook salmon produced in the Sacramento Basin. Furthermore, the San Joaquin River Restoration Program goal of re-establishing an experimental population of CV spring-run Chinook salmon in the San Joaquin River basin will create the potential that CV spring-run Chinook salmon will be present in the southern Delta and San Joaquin River regions of the Bay-Delta area over the lifetime of the proposed action. However, based on the lack of established non-experimental populations in these tributaries, and the fact that we currently do not have enough information to determine whether these individuals are part of the listed CV spring-run Chinook salmon ESU, the effects of the proposed action in the Stanislaus and San Joaquin Rivers are not analyzed for CV spring-run Chinook salmon in this Opinion.

An experimental population of spring-run Chinook salmon has been designated under section 10(j) of the ESA in the San Joaquin River from Friant Dam downstream to its confluence with the Merced River (78 FR 79622 2013; Snider and Titus 2000a), and spring-run Chinook salmon are currently being reintroduced to the San Joaquin River. The experimental population area in the San Joaquin River is outside the action area. When these fish migrate to and from the ocean, they will pass through the action area, where they are considered part of the non-experimental CV spring-run Chinook salmon ESU. A conservation stock of spring-run Chinook is being developed at the San Joaquin River Interim Conservation and Research Facility at Friant Dam and juveniles have been released annually since 2014 to the lower San Joaquin River (California Department of Fish and Wildlife 2014b). In 2019, the San Joaquin River Restoration Program released 168,495 San Joaquin River Conservation and Research Facility spring-run Chinook salmon juveniles to the San Joaquin River in Reach 5 of the Restoration Area (Ferguson 2019). As of May 2019, more than 10 adult fish have been detected returning to the San Joaquin River. In the spring of 2018, juveniles released in Reach 1 of the Restoration Area were detected at the

Tracy Fish Collection Facility, demonstrating volitional passage of juvenile spring-run through the San Joaquin River for the first time in 60 years (National Marine Fisheries Service 2019e).

NMFS discusses the San Joaquin experimental population and associated 4(d) rule with respect to findings under this consultation further in the introduction.

Some non-natal juvenile CV spring-run Chinook salmon rearing has been observed in the Lower American River (Snider and Titus 2000a). However, there is no longer a spawning population of CV spring-run Chinook associated with that system. Due to this, and a lack of information on the number of rearing juveniles and their population of natal origin within this ESU, the effects of the proposed action in the American River are not analyzed for CV spring-run Chinook salmon in this Opinion.

Assessing the temporal occurrence of each life stage of spring-run Chinook salmon is done through analysis of monitoring data in the Sacramento River and select tributaries; monitoring in the Delta; and salvage data from the Tracy Fish Collection Facility and Skinner Delta Fish Protective Facility in the south Delta (CVP and SWP, respectively). Table 9 and Table 10 show the temporal occurrence of adult and juvenile CV spring-run Chinook salmon at locations in the action area.

Table 9. Temporal occurrence of Central Valley spring-run Chinook salmon by life-stage in the mainstem Sacramento River.

Relative Abundance	High (▼)												Medium (⊠)								Low (#)				None (-)
(a) Adult Migration	Month																							
Location	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
Sac. River Basin [a,b]	-	-	-	-	⊠	⊠	⊠	⊠	▼	▼	▼	▼	⊠	⊠	⊠	⊠	⊠	⊠	#	-	-	-	-	-
Sac. River Mainstem [b,c]	-	#	#	#	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	#	#	-	-	-	-	-	-	-	-
Adult Holding [a,b]	-	-	#	#	⊠	⊠	▼	▼	▼	▼	▼	▼	▼	▼	▼	⊠	⊠	#	#	-	-	-	-	-
Adult Spawning [a,b,c]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	#	⊠	▼	▼	⊠	#	-	-	-	-
(b) Juvenile Migration	Month																							
Location	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
Sac. River at Red Bluff Diversion Dam [c]	▼	▼	#	#	#	#	#	#	#	-	-	-	-	-	-	-	-	-	-	-	▼	▼	▼	▼
Sac. River at Knights Landing[h]	⊠	⊠	⊠	⊠	▼	▼	▼	▼	⊠	⊠	-	-	-	-	-	-	-	-	-	-	⊠	⊠	▼	▼

Sources: [a] Yoshiyama et al. (1998); [b] Moyle (2002); [c] Myers et al. (1998); [d] Lindley et al. (2004); [e] California Department of Fish and Game (1998); [f] McReynolds et al. (2007); [g] Ward et al. (2003); [h] Snider and Titus (2000b)

Note: Yearling 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 spring-run Chinook salmon emigrate during the first spring after they hatch.

Table 10. Temporal occurrence of Central Valley spring-run Chinook salmon by life-stage in the Delta.

Relative Abundance	**High (▼)**			**Medium (☒)**			**Low (#)**			**None (-)**		
Life Stage	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult [1]	☒	▼	▼	▼	☒	☒	-	-	-	-	-	-
Juvenile [2]	#	#	#	▼	☒	-	-	-	-	-	-	#
Salvaged [3]	#	#	☒	▼	☒	-	-	-	-	-	-	-

[1]*Adults enter the Bay late January to early February* (California Department of Fish and Game 1998) *and enter the Sacramento River in March* (Yoshiyama et al. 1998). *Adults travel to tributaries as late as July* (Lindley et al. 2004). *Spawning occurs September to October* (Moyle 2002).
[2]*Juvenile presence in the Delta based on Delta Juvenile Fish Monitoring Program data.*
[3]*Juvenile presence in the Delta based on salvage data* (National Marine Fisheries Service 2016a).

Adult spring-run Chinook salmon enter the San Francisco estuary to begin their upstream spawning migration in late January and early February (California Department of Fish and Game 1998). They enter the Sacramento River from March to September, primarily in May and June (Moyle 2002; Yoshiyama et al. 1998). Generally, adult spring-run Chinook salmon are sexually immature when they enter freshwater habitat and must hold in deep pools for up to several months in preparation for spawning (Moyle 2002). The Delta and Sacramento River provide a critical migration corridor for spawning adults, allowing them access to spawning grounds upstream.

The Sacramento River mainly functions as both rearing habitat for juveniles and the primary migratory corridor for outmigrating juveniles and spawning adults for all the Sacramento River basin populations. The juvenile life stage of CV spring-run Chinook salmon exhibits varied rearing behavior and outmigration timing. Juveniles may reside in the action area for 12–16 months (these individuals are characterized as "yearlings"), while some may migrate to the ocean as young-of-the-year (National Marine Fisheries Service 2014b).

Adult CV spring-run Chinook salmon migrate into Clear Creek from April to August, and peak passage occurs in May and June (Clear Creek Technical Team 2018; Giovannetti and Brown 2013). 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.

CV spring-run Chinook salmon migrate into Clear Creek several months before fall-run Chinook salmon migration begins. A large portion of the CV spring-run Chinook salmon typically moves to the upstream 10 miles of the creek, to hold in the colder water of the canyon. Before the arrival of fall run Chinook salmon, and just prior to the onset of CV spring-run Chinook salmon spawning, the FWS installs and operates a temporary weir each year to physically separate the two runs during spawning to minimize hybridization and redd superimposition. The segregation weir is placed at river mile 7.5 or 8.2 in late August and left in place until early November after the peak of fall-run Chinook salmon spawning when there is no chance of hybridization, and risk of redd superimposition is very low. The weir location and timing were determined to protect the most CV spring-run Chinook salmon, while minimizing effects to other salmonids (Giovannetti and Brown 2013). Any CV spring-run Chinook salmon downstream of the weir are likely to hybridize with fall-run Chinook salmon, or redds would be subject to redd superimposition.

Spawning occurs from early September through October, and peaks in late-September (Giovannetti and Brown 2013). Egg incubation occurs from September to early February based on redd timing. Based on juvenile passage indices from the FWS rotary screw trap (river mile 8.4), fry emergence begins in early November, peak passage occurs from mid-November through January, and 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). While the majority of juvenile CV spring-run Chinook salmon outmigrate 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 Delta is utilized by juveniles prior to entering the ocean. Juvenile spring-run Chinook salmon use Suisun Marsh extensively as a migratory pathway, though they likely move through quickly based on their size upon entering the bay (as compared to fall-run, which enter this area at a smaller size and likely exhibit rearing behavior prior to continuing their outward migration) (Brandes and McLain 2001; Williams

2012). 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 10). Like adult 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 (young of the year) are present in the Bay-Delta region as they migrate to the ocean in the spring. Yearling spring-run Chinook salmon are expected to enter the Delta in late fall and early winter (late October through January). Juvenile spring-run Chinook salmon are expected to be present in the northern Delta region from December through May with a peak presence in March and April (Barnard et al. 2015; Miller et al. 2017; Speegle et al. 2013; U.S. Fish and Wildlife Service 2019; University of Washington Columbia Basin Research 2019) (Table 10, Figure 17, and Figure 18). Although the exact number of spring-running Chinook salmon in the San Joaquin basin is unknown, juvenile and adult spring-run Chinook salmon use the portion of the lower San Joaquin River within the Delta as a migratory pathway.

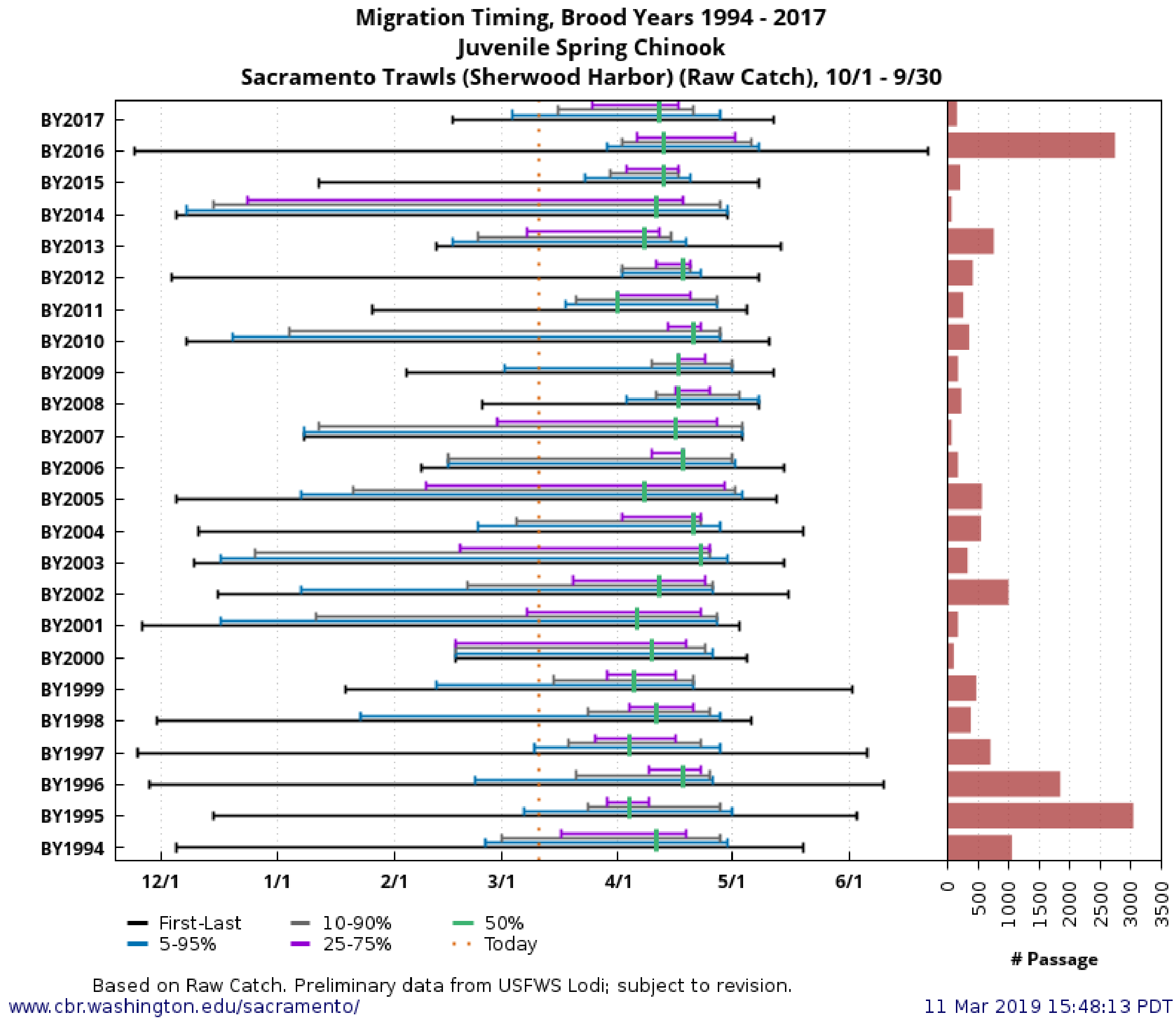


Figure 17. Juvenile Central Valley spring-run Chinook salmon migration timing past the Sherwood Harbor – Sacramento trawl location for brood years 1994 to 2017.

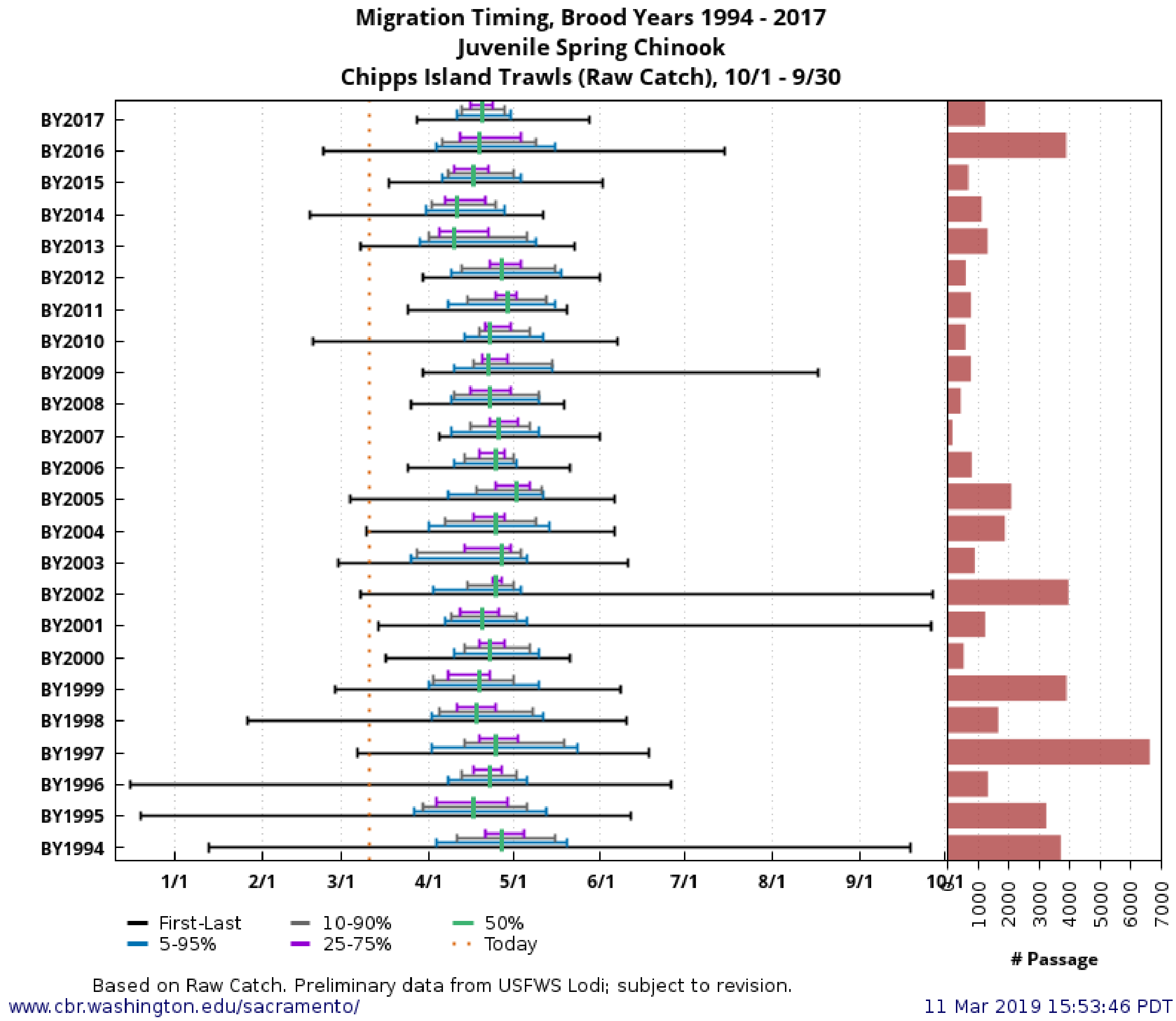


Figure 18. Juvenile Central Valley spring-run Chinook salmon migration timing past the Chipps Island trawl location for brood years 1994 to 2017.

Once in the ocean, juvenile Chinook salmon tend to stay along the California coast (Moyle 2002). This is likely due to the high productivity caused by the upwelling of the California current. These food-rich waters are important to ocean survival, as indicated by a decline in survival during years when the current does not flow as strongly and upwelling decreases (Lindley et al. 2009; Moyle 2002). After entering the ocean, juveniles become voracious predators on small fish and crustaceans and invertebrates such as crab larvae and amphipods. As they grow larger, fish increasingly dominate their diet. They typically feed on whatever pelagic plankton is most abundant, usually herring, anchovies, juvenile rockfish, and sardines. The ocean stage of the Chinook salmon life cycle lasts 1 to 5 years. Information on salmon abundance and distribution in the ocean is based upon coded-wire tag recoveries from ocean fisheries. For more than 30 years, the marine distribution and relative abundance of specific stocks, including ESA-listed ESUs, have been estimated using a representative CWT hatchery stock (or stocks) to serve as proxies for the natural and hatchery-origin fish within ESUs. One extremely important assumption of this approach is that hatchery and natural stock components are similar in their life histories and ocean migration patterns (Berejikian et al. 1999).

There are no spawning areas in the Bay-Delta region that could be used by adult 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 spring-run Chinook salmon are reaching the size that smoltification occurs, and the majority of smolts would be moving downriver to enter the Delta on their emigration to the ocean. Spring-run Chinook salmon smolt outmigration 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 will remain in the tributaries through the summer and outmigrate the following fall and winter as yearlings (Table 10). 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 (Table 10). In the San Joaquin River basin, adult migration is also likely to be strongly influenced by the flow levels in the San Joaquin River basin that provides access to the upstream holding and spawning areas. The broodstock for the spring-run Chinook salmon experimental population came from the Sacramento River basin (Feather River Fish Hatchery spring-run Chinook salmon) and are expected to exhibit similar migration timing behavior for both adult and juvenile life stages in the San Joaquin River basin.

Monitoring the Sacramento River mainstem during spring-run Chinook salmon spawning timing indicates that some spawning occurs in the river. Genetic introgression between fall-run and spring-run CV Chinook salmon populations has likely occurred due to lack of physical separation, temporal overlap, and hatchery practices (California Department of Water Resources 2001). The Central Valley TRT estimated that historically there were 18 or 19 independent populations of CV spring-run Chinook salmon, along with a number of dependent populations, all within four distinct geographic regions, or diversity groups (Lindley et al. 2004). Of these populations, only three independent populations currently exist (Mill, Deer, and Butte creeks, tributary to the upper Sacramento River), and they represent only the northern Sierra Nevada diversity group (National Marine Fisheries Service 2014b). Additionally, smaller, dependent populations in Antelope and Big Chico creeks and the Feather and Yuba rivers in the northern Sierra Nevada diversity group (California Department of Fish and Game 1998). The northwestern California diversity group contains two small persisting populations, in Clear and Beegum creeks. In the basalt and porous lava diversity group, in addition to a potential returning population to the Sacramento River, downstream of Keswick Dam, a small population in Battle Creek is currently persisting (Figure 19).

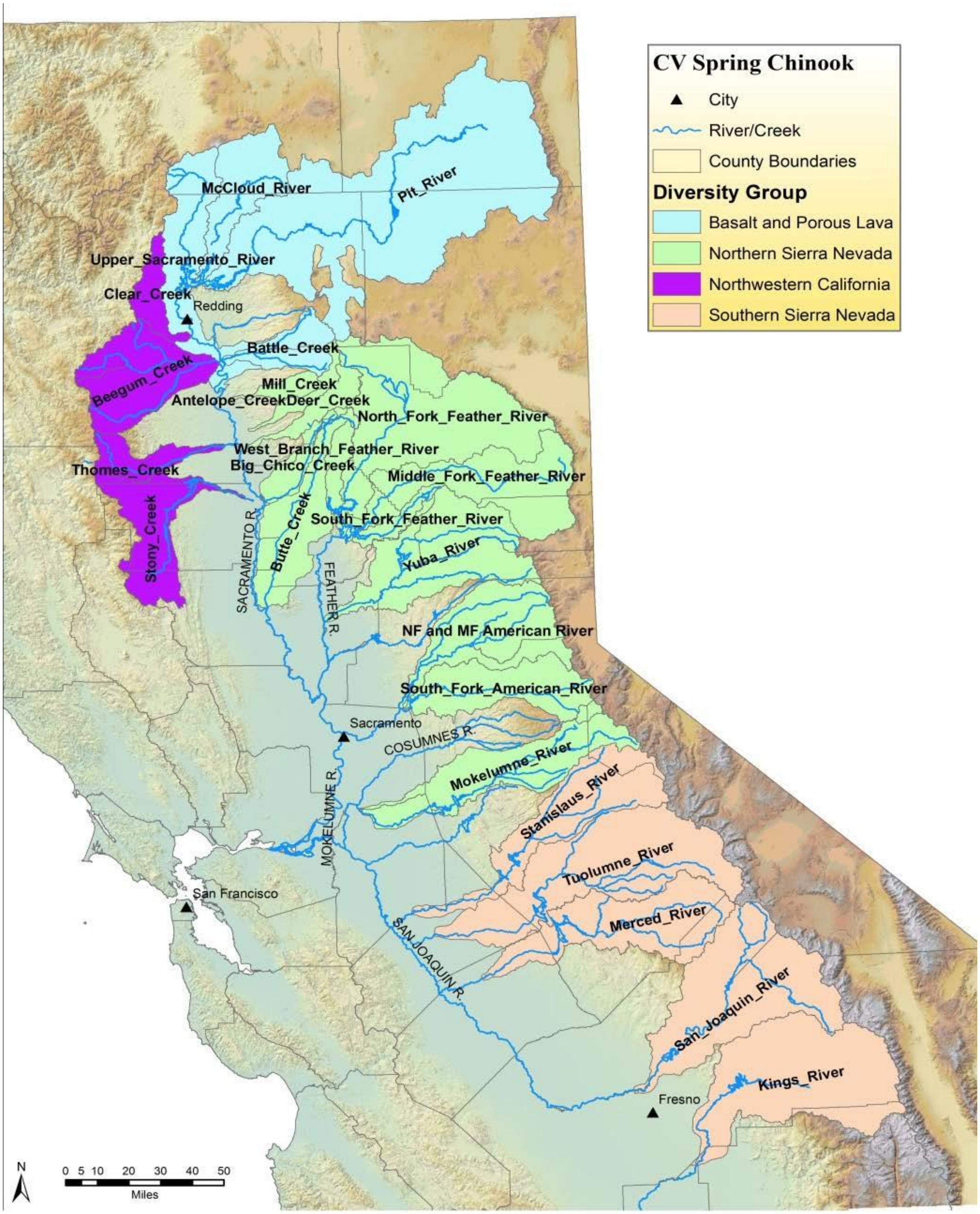


Figure 19. Diversity groups for the Central Valley Spring-run Chinook Salmon Evolutionarily Significant Unit.

Sacramento River tributary populations in Mill, Deer, and Butte creeks are likely the best trend indicators for the CV spring-run Chinook salmon ESU. Generally, these streams have shown a positive escapement trend since 1991, displaying broad fluctuations in adult abundance. The Feather River Fish Hatchery spring-run Chinook salmon population represents the only remaining evolutionary legacy of the spring-run Chinook salmon populations that once spawned above Oroville Dam, and has been included in the ESU based on its genetic linkage to the natural spawning population and the potential development of a conservation strategy for the hatchery program ((70 FR 37160 2005); June 28, 2005). Hatchery-produced CV spring-run Chinook salmon may affect ESU diversity through (1) introgression with CV fall-run Chinook salmon due to overlap in spawn timing; (2) straying of Feather River Fish Hatchery spring-run into natural-origin CV spring-run spawning habitat; and (3) disproportionately high levels of returning spawners in comparison to natural-origin fish (National Marine Fisheries Service 2016a).

Counts of Chinook salmon redds in September are typically used as an indicator of the CV spring-run Chinook salmon population abundance. Less than 15 Chinook salmon redds per year were observed in the Sacramento River from 1989 to 1993, during September aerial redd counts. Redd surveys conducted in September from 2001 to 2011 have observed an average of 36 Chinook salmon redds from Keswick Dam downstream to the Red Bluff Diversion Dam, ranging from 3 to 105 redds; from 2012 to 2015, redds observed were close to zero except in 2013, when 57 redds were observed in September (California Department of Fish and Wildlife 2017b). Currently, Clear Creek is the only tributary within this diversity group that has a with an independent population of spring-run Chinook salmon. Beegum Creek, which is a tributary to Cottonwood Creek also has periodic returns of adult CV spring-run Chinook salmon, but water temperatures in Beegum Creek can reach lethal levels during the summer months, and it is not known if there is successful spawning. Juvenile production as estimated from rotary traps at Red Bluff Diversion Dam indicate that juvenile outmigration of CV spring-run Chinook salmon from Clear Creek and the upper Sacramento River has fluctuated since 2013. Estimates of outmigrants ranged from over 120,000 to 1.7 million between 2013 and 2015 brood years, declining more recently to just under one million in brood year 2016 and just over 300,000 in brood year 2017, and then jumping back up to over 3.3 million juveniles outmigrating for brood year 2018 (U. S. Fish and Wildlife Service 2019).

The CV spring-run Chinook salmon ESU comprises two known genetic complexes. Analysis of natural and hatchery spring-run Chinook salmon stocks in the Central Valley indicates that the northern Sierra Nevada diversity group spring-run Chinook salmon populations in Mill, Deer, and Butte creeks retain genetic integrity as opposed to the genetic integrity of the Feather River population, which has been somewhat compromised by introgression with the fall-run ESU (Cavallo et al. 2011; Garza et al. 2008; Good et al. 2005).

Because the populations in Butte, Deer and Mill creeks are the best trend indicators for ESU viability, we can evaluate risk of extinction based on VSP parameters in these watersheds. Over the long term, these three remaining populations are considered to be vulnerable to anthropomorphic and naturally occurring catastrophic events. The viability assessment of CV spring-run Chinook salmon conducted during NMFS' 2010 status review (National Marine Fisheries Service 2011a) found that the biological status of the ESU had worsened since the last status review (2005). In 2012 and 2013, most tributary populations increased in returning adults, averaging over 13,000. The 2014 returns were lower again, just over 5,000 fish, indicating the ESU remains highly fluctuating. The most recent status review, conducted in 2015 (National

Marine Fisheries Service 2016a), looked at promising increasing populations in 2012 to 2014 (Figure 20). However, CDFW has since documented critically low spring-run Chinook salmon adult returns to Mill and Deer creeks for multiple years, due in part to one of California's most severe and prolonged droughts on record (December 2011 to March 2017). From 2015 through 2018, both Mill and Deer creeks spring-run Chinook salmon populations had adult returns below 500. The final 2018 escapement estimates for Mill and Deer creeks were 152 and 159 CV spring-run Chinook salmon, respectively (California Department of Fish and Wildlife 2019a). These estimates are among the lowest number of adults returning to Mill and Deer Creeks since records began in 1960.

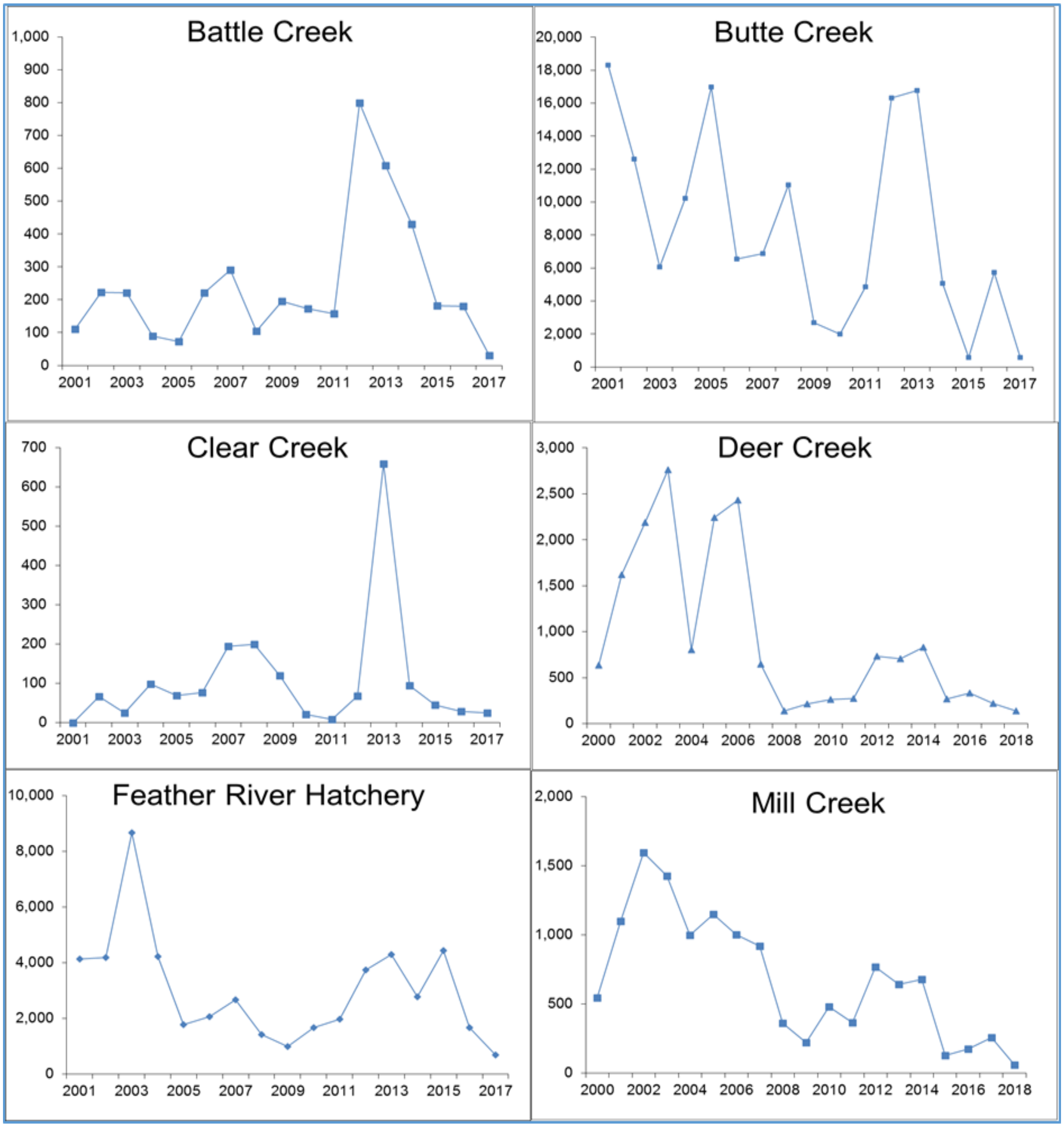


Figure 20. Central Valley spring-run Chinook salmon adult abundance.

Data for 2018 are preliminary estimates from the California Department of Fish and Wildlife and are subject to change.

Mill Creek preliminary data from 2019 indicate adult counts may be reduced further compared to 2018. However, these data also indicate that escapement in Deer Creek has more than doubled in 2019 compared to 2018 (California Department of Fish and Wildlife 2019b). Preliminary data from Butte Creek indicate an estimated 6,253 spawning adults may have returned to this reach alone in 2019 (Garman 2019). Battle Creek is also expected to have over 40 adults returning in 2019, and Clear Creek over 60 adults, if final counts are consistent with preliminary data (Garman 2019). Returns of adult CV Spring Chinook salmon in the Feather River have increased following the extreme drought years, from a low of 762 in 2017 to over 7,200 adults in 2018, and preliminary data suggest that 2019 adult returns may be nearly twice that of 2018 (National Marine Fisheries Service 2019d).

Mill and Deer Creeks spring-run Chinook salmon represent two of only three extant independent Chinook salmon populations in California's Central Valley, and therefore are vital to the health of the CV spring-run Chinook salmon ESU. In response to the recent reduction in adult escapement, NMFS and CDFW are jointly developing an Emergency Spring-run Action Plan, which aims to identify and outline the implementation of immediate, targeted efforts that are vital for stabilizing the populations that are most at risk (Mill, Deer, and Butte creeks). Immediate management actions under consideration include efforts to increase flows, possible implementation of a supplementation program (utilizing hatchery-origin CV spring-run Chinook salmon), and completion of fish passage improvement projects.

CV spring-run Chinook salmon adults are vulnerable to climate change because they over-summer in freshwater streams before spawning in autumn (Thompson et al. 2011). CV spring-run Chinook salmon spawn primarily in the tributaries to the Sacramento River, and those tributaries without cold water refugia (usually input from springs) will be more susceptible to impacts of climate change. Even in tributaries with cool water springs, in years of extended drought and warming water temperatures, unsuitable conditions may occur. Additionally, juveniles often rear in the natal stream for one to two summers prior to emigrating, and would be susceptible to warming water temperatures (National Marine Fisheries Service 2016a). In Butte Creek, fish are limited to low elevation habitat that is currently thermally marginal, as demonstrated by high summer mortality of adults in 2002 and 2003, and will become intolerable within decades if the climate warms as expected. Ceasing water diversion for power production from the summer holding reach in Butte Creek resulted in cooler water temperatures, more adults surviving to spawn, and extended population survival time (Mosser et al. 2013).

Overall, the SWFSC concluded in their viability report that the status of CV spring-run Chinook salmon (until 2014) has probably improved since the 2010/2011 status review and that the ESU's extinction risk may have decreased during that timeframe (Williams et al. 2016). The CV spring-run Chinook salmon ESU remains at moderate risk of extinction based on the severity of the drought and the low escapements, as well as increased pre-spawn mortality in Butte, Mill, and Deer creeks in 2015. There is concern that these CV spring-run Chinook salmon strongholds will deteriorate into high extinction risk in the coming years based on the population size or rate of decline criteria (National Marine Fisheries Service 2016a). This predicted trend has been validated in recent years through escapement data collected by CDFW for Mill and Deer creeks (California Department of Fish and Wildlife 2019a), with adult returns below 500 individuals for the fourth consecutive year (2015-2018) (Figure 20).

In summary, the extinction risk for the CV spring-run Chinook salmon ESU remains at moderate risk of extinction (National Marine Fisheries Service 2016a). Based on the severity of the drought and the low escapements, as well as increased pre-spawn mortality in Butte, Mill, and Deer creeks in 2015, there is concern that these CV spring-run Chinook salmon strongholds will deteriorate into high extinction risk in the coming years based on the population size or rate of decline criteria (National Marine Fisheries Service 2016a). This predicted trend has been validated in recent years through escapement data collected by CDFW for Mill and Deer creeks(California Department of Fish and Wildlife 2019a). With adult returns below 500 individuals for the fourth consecutive year (2015-2018), these populations are at an increased risk of extinction (Lindley et al. 2007). CDFW and NMFS intend to implement the suite of actions described in the draft Emergency Spring-run Action Plan as soon as possible upon finalizing the plan.

6.4 Designated Critical Habitat for Central Valley Spring-run Chinook Salmon

The geographical range of designated critical habitat 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 ((70 FR 52488 2005); Figure 21).

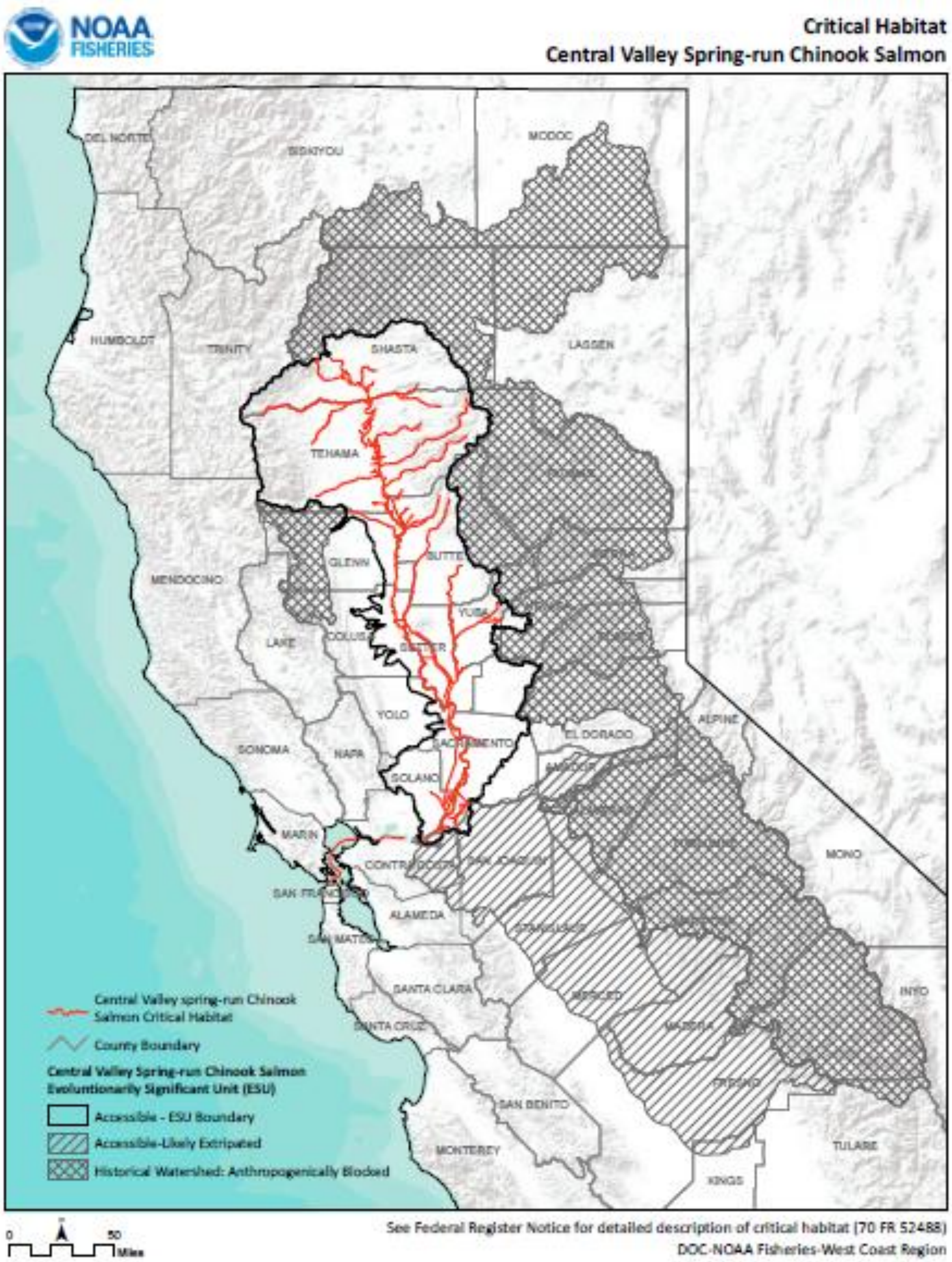


Figure 21. Designated critical habitat for Central Valley spring-run Chinook salmon Evolutionarily Significant Unit.

The critical habitat designation for CV spring-run Chinook salmon lists the essential physical and biological features ((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, and

(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 fresh- and saltwater; (ii) natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels; and (iii) juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation.

Within the action area, spawning habitat for CV spring-run Chinook salmon is currently limited to the mainstem of the Sacramento River between Red Bluff and Keswick Dam, and Clear Creek. The physical and biological features 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 (Good et al. 2005; Jarrett and Killam 2014; National Marine Fisheries Service 2009b; Wright and Schoellhamer 2004). 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 physical and biological features have been degraded from their historical condition within the action area. In the Sacramento River, 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 winter-run Chinook salmon, CV spring-run Chinook salmon 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 spring-run Chinook salmon 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).

Within the action area of the proposed action, the estuarine physical and biological features include the legal Delta, encompassing significant reaches of the Sacramento River that are tidally influenced (70 FR 52488). Estuarine habitat in the Delta is significantly degraded from its historical condition due to levee construction, shoreline development, and dramatic alterations to the natural hydrology of the system due to water export operations (National Marine Fisheries Service 2014b). Though critical habitat for CV spring-run occurs in the north Delta and not the interior or south Delta, entrainment into the interior Delta may occur during Delta Cross Channel gate openings if coinciding with migration. The 2014 drought year prompted protections for CV spring-run at the Delta Cross Channel (National Marine Fisheries Service 2016a). Reverse flows in the central and south Delta resulting from water exports may exacerbate interior Delta entrainment by confounding flow and temperature-related migratory cues in outmigrating juveniles. The presence of these stressors, which cause altered migration timing and routing, degrade critical habitat physical and biological features related to rearing and migration.

Although the current conditions of CV spring-run Chinook salmon critical habitat are significantly degraded, the spawning habitat, migratory corridors, and rearing habitat that remain are considered to have high intrinsic value for the conservation of the species.

6.5 California Central Valley Steelhead

- Originally listed as threatened ((63 FR 13347); March 19, 1998)
- Reaffirmed as threatened ((71 FR 834); January 5, 2006)
- Designated critical habitat ((70 FR 52488); September 2, 2005)

The federally listed DPS of CCV steelhead and designated critical habitat occur in the action area and may be affected by the proposed action.

Information on the status of CCV steelhead consist of three types of data sources: direct adult counts, redd counts, and smolt counts. Adult data are the best source, but are complicated by inconsistent counting methods and reporting formats among the hatcheries and weirs. Redd counts represent valuable information from rivers where there are no dams or weirs to block adult migration, but the actual number of adults represented by each redd are unknown. Sampling of smolts in trawls and at the salvage facilities gives us an idea of relative productivity for a region and between hatchery and wild sources, but the survival of these smolts is unknown, and the counts cannot give us estimates of adult abundance. Implementation of CDFW's Central Valley Steelhead Monitoring Program should result in greater consistency in reporting of adult escapement and estimates of abundance that are currently lacking (National Marine Fisheries Service 2016b).

Historic CCV steelhead run sizes are difficult to estimate given the paucity of data, but may have approached one to two million adults annually (McEwan 2001). By the early 1960s, the CCV steelhead run size had declined to about 40,000 adults (McEwan 2001). Current abundance data are limited to returns to hatcheries and redd surveys conducted on a few rivers. The hatchery data are the most reliable, as redd surveys for CCV steelhead are often made difficult by high flows and turbid water usually present during the winter-spring spawning period.

The majority of CCV steelhead originate in the Sacramento River basin and its multiple tributaries and are comprised 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 Calaveras River and San Joaquin River basin and are part of the Southern Sierra Nevada Diversity Group. Assessing the temporal occurrence of each life stage of CCV steelhead in the action area is done through analysis of monitoring data in the Sacramento River and select tributaries; monitoring in the Delta; and salvage data from the Tracy Fish Collection Facility and Skinner Delta Fish Protective Facility in the south Delta (CVP and SWP). Table 11 and Table 12 shows the temporal occurrence of adult and juvenile CCV steelhead at locations in the action area.

Table 11. Temporal occurrence of California Central Valley steelhead by life-stage at locations in the action area.

Relative Abundance	**High (▼)**							**Medium (⊠)**						**Low (#)**					**None (-)**					
Migration Life Stage: (a) Adult	Month																							
Location	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
[1]Sacramento R. at Fremont Weir	#	#	#	#	#	-	-	-	-	-	-	#	#	#	#	⊠	▼	▼	▼	⊠	#	#	#	#
[2]Sacramento R. at Red Bluff Diversion Dam	#	#	#	#	#	#	#	#	#	#	#	#	#	#	#	#	⊠	⊠	▼	⊠	#	#	#	#
[3]San Joaquin River	▼	▼	⊠	⊠	#	#	-	-	-	-	-	-	#	#	#	#	⊠	⊠	⊠	⊠	⊠	⊠	▼	▼
Migration Life Stage: (b) Juvenile	Month																							
Location	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
[1,2]Sacramento R. near Fremont Weir	#	#	#	#	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	#	#	#	#	#	#	⊠	⊠	⊠	⊠	#	#
[4]Sacramento R. at Knights Landing	▼	▼	▼	▼	⊠	⊠	⊠	⊠	#	#	#	#	-	-	-	-	-	-	-	-	#	#	#	#
[5]Chipps Island (clipped)	⊠	⊠	▼	▼	⊠	⊠	#	#	#	#	-	-	-	-	-	-	-	-	-	-	-	-	#	#
[5]Chipps Island (unclipped)	⊠	⊠	⊠	⊠	▼	▼	▼	▼	▼	▼	⊠	⊠	#	#	-	-	-	-	-	-	-	#	#	#
[6]San Joaquin R. at Mossdale	-	-	#	#	⊠	⊠	▼	▼	▼	▼	#	#							#	#	-	-	-	-

Sources: [1] Hallock et al. (1957); [2]McEwan (2001); [3]California Department of Fish and Game (2007); [4]NMFS analysis of 1998-2018 CDFW data; [5]NMFS analysis of 1998-2018 USFWS data; [6]NMFS analysis of 2003-2018 USFWS data.

Table 12. Temporal occurrence of California Central Valley steelhead by life-stage in the Delta.

Relative Abundance	High (▼)			Medium (☒)			Low (#)		None (-)		
Life Stage	Month										
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult [1]	☒	☒	☒	☒	▼	-	#	☒	▼	☒	☒	☒
Juvenile [2]	#	☒	☒	▼	▼	#	#	-	#	-	-	#
Salvaged [3]	☒	▼	▼	☒	#	#	-	-	-	-	#	#

1Adult presence was determined using information in Moyle (2002), Hallock et al. (1961), and California Department of Fish and Wildlife (2015b).
2Juvenile presence in the Delta was determined using Delta Juvenile Fish Monitoring Program data.
3Months in which salvage of wild juvenile steelhead at State and Federal pumping plants occurred; values in cells are salvage data reported by the facilities (He and Stuart 2016).

Spawning adults enter the San Francisco Bay estuary and Delta from August to November (with a peak in September (Hallock et al. 1961). Spawning occurs in a number of tributaries to the Sacramento River, to which the Delta and Sacramento River serve as key migratory corridors. Spawning occurs from December to April, with a peak in January through March, in rivers and streams where cold, well oxygenated water is available (Hallock et al. 1961; McEwan and Jackson 1996; Williams 2006). Adults typically spend a few months in freshwater before spawning (Williams 2006) but very little is known about where they hold between entering freshwater and spawning in rivers and streams. Utilization of the Delta by adults is also poorly understood.

Juvenile CCV steelhead rear in cool, clear, fast-flowing streams and are known to prefer riffle habitat over slower-moving pools. Little is known about the rearing behavior of juveniles in the Delta. They are thought to exhibit short periods of rearing and foraging in tidal and non-tidal marshes and other shallow areas prior to their final entry into the ocean.

Adult steelhead begin to migrate through the northern portion of the Bay-Delta region (lower Sacramento River) starting 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”). The majority of adult 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).

Natural CCV steelhead juveniles (smolts) can 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 (Barnard et al. 2015; Miller et al. 2017; Speegle et al. 2013; University of Washington Columbia Basin Research 2019); Figure 22; Figure 23) and CVP and SWP fish salvage facilities (California Department of Fish and Wildlife 2018b). 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 mm FL, 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.

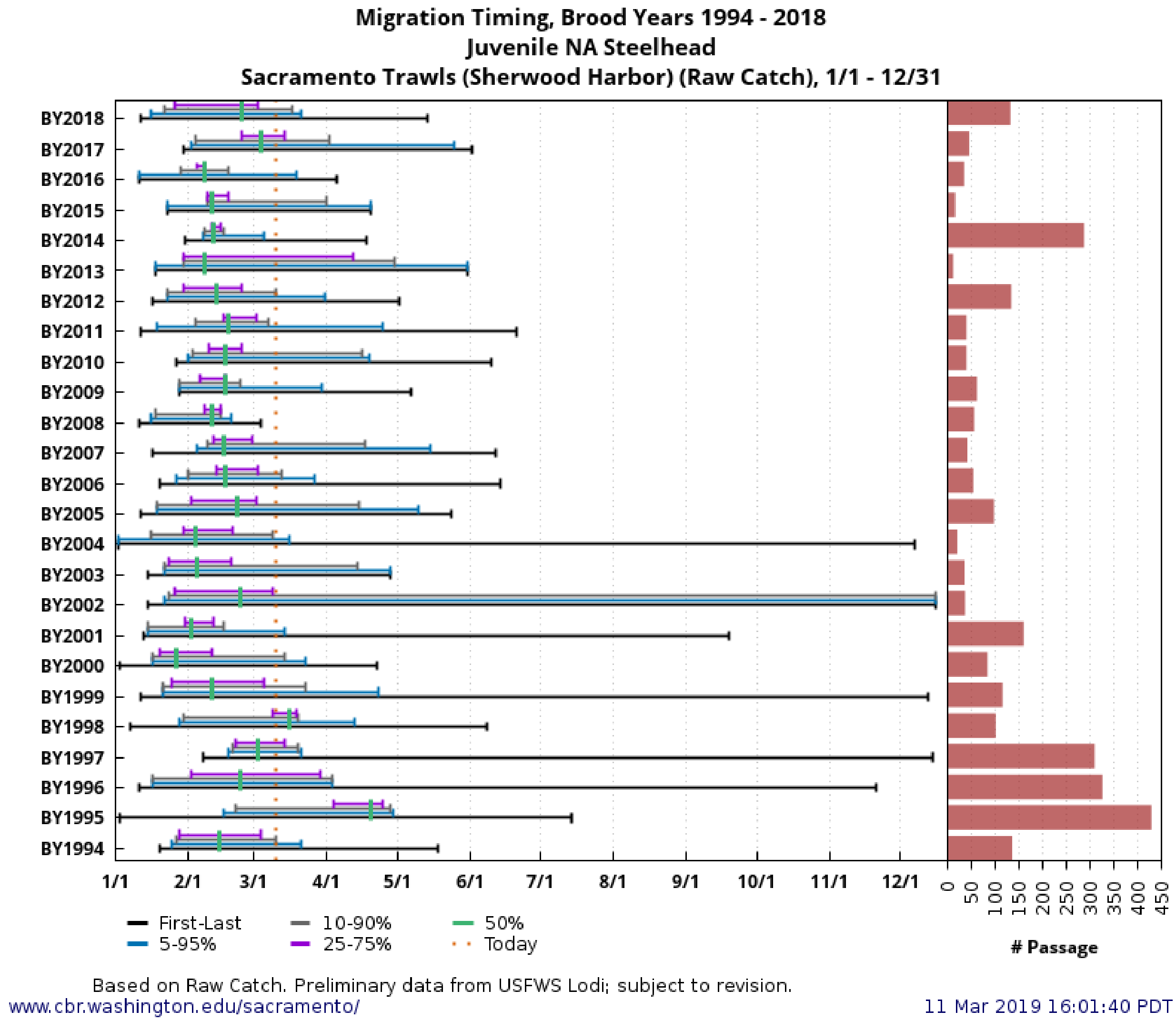


Figure 22. Juvenile unclipped California Central Valley steelhead migration timing past the Sherwood Harbor – Sacramento trawl location for brood years 1994 to 2017.

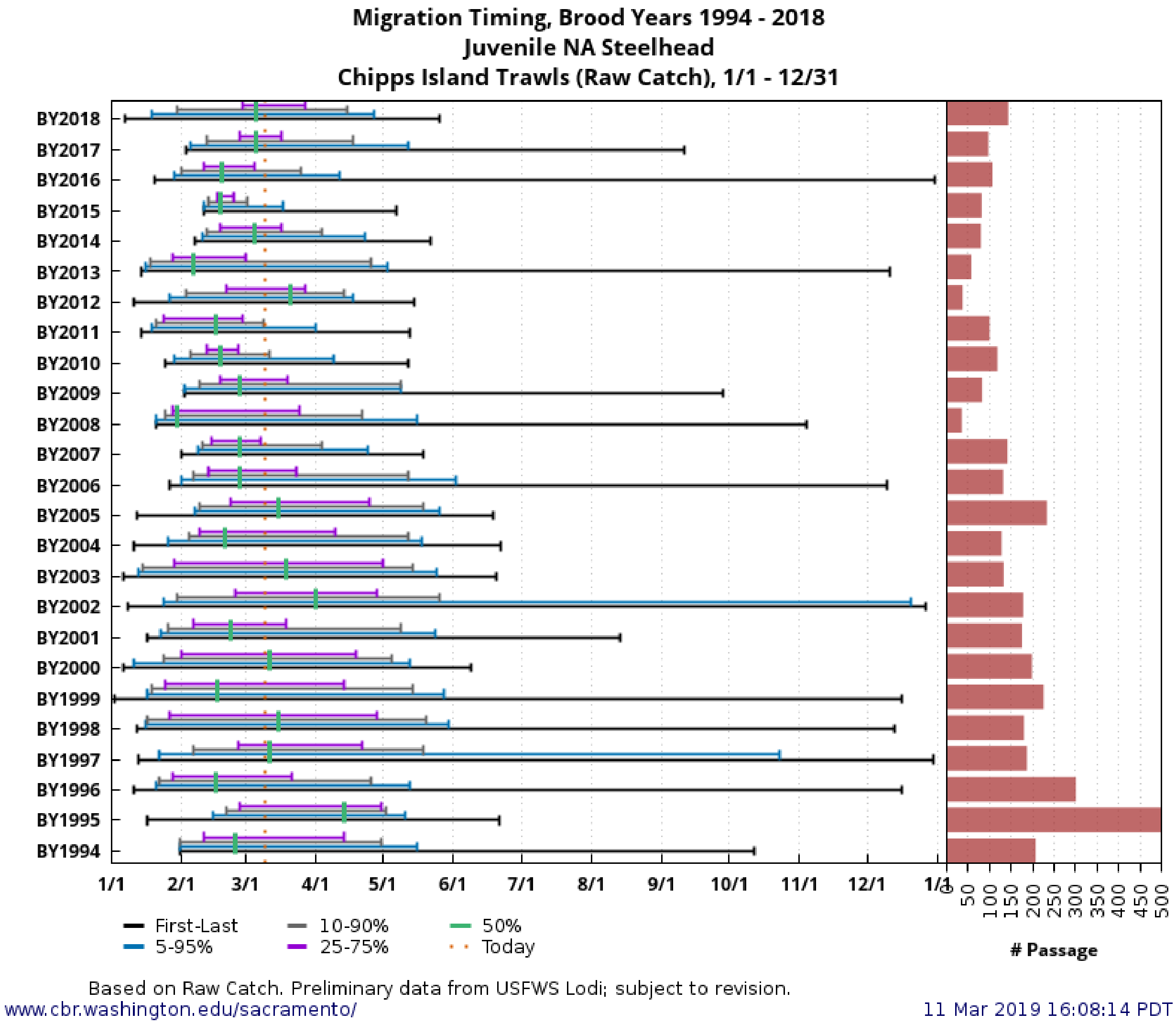


Figure 23. Juvenile unclipped California Central Valley steelhead migration timing past the Chipps Island trawl location for brood years 1994 to 2017.

Adult CCV steelhead migration into Clear Creek begins in late-August and continues through April. 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 beginning in mid-January, and 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 FWS have also documented the presence of juvenile CCV steelhead in the summer and fall months. Juvenile CCV steelhead rear in fresh water from one to three years. 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 capture in the rotary screw traps, and passage estimates may underestimate these life stages.

The portion of the lower San Joaquin River within the Delta is used by migrating adult and juvenile CCV steelhead to reach spawning and rearing grounds in the tributaries (California Department of Fish and Wildlife 2013b; FISHBIO 2012). Adult 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 through January period, based on Stanislaus River fish weir counts. Adult CCV steelhead will 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 (Table 12).

About 80 percent of the historical spawning and rearing habitat once used by anadromous steelhead in the Central Valley is now upstream of impassible dams (Lindley et al. 2006). Many historical populations of CCV steelhead are entirely above impassable barriers and may persist as resident or adfluvial rainbow trout, although they are presently not considered part of the DPS. Steelhead are well-distributed throughout the Central Valley below the major rim dams (Good et al. 2005; National Marine Fisheries Service 2016b). Most of the steelhead populations in the Central Valley have a high hatchery-origin component, including those from Battle Creek (adults intercepted at the Coleman NFH weir), American River, Feather River, and Mokelumne River.

The Lower American River contains a naturally spawning population of CCV steelhead, which spawn downstream of Nimbus Dam. The dam is an impassable barrier to anadromous fish, isolating historical spawning habitat located in the North, Middle and South forks of the upper American River. The American River population is small, with only a few hundred individuals returning to spawn each year (U.S. Bureau of Reclamation 2015). Spawning adults have been observed with intact adipose fins indicating that a portion of the in-river spawning population is of wild origin (Hannon 2013). Juvenile *O. mykiss* (anadromous and resident forms) have been observed to occupy fast-flowing riffle habitat in the Lower American River, which is consistent with known life history traits of this species.

Redd counts are conducted in the American River and in Clear Creek (Shasta County). An average of approximately 123 redds have been counted on the American River from 2002 to 2018 (American River Group 2017; American River Group 2018; Cramer Fish Sciences 2016). An average of 183 redds have been counted in Clear Creek from 2001 to 2017 following the removal of Saeltzer Dam, which allowed steelhead access to additional spawning habitat. The Clear Creek redd count data estimated a range from 100 to 1,023 spawning adult steelhead on average each year, indicating an upward trend in abundance since 2006 (U.S. Fish and Wildlife Service 2015a).

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 (Table 12), with only a small number of fish being salvaged through the summer at the CVP and SWP fish salvage facilities. Juvenile 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 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.

Nimbus Fish Hatchery, located on the Lower American River adjacent to Nimbus Dam, produces the anadromous form of *O. mykiss*. Steelhead from Nimbus Fish Hatchery are not included in the CCV steelhead DPS due to genetic integrity concerns from use of out-of-basin broodstock (71 FR 834 2006). To specifically address this issue and in response to RPA II.6.1 contained in the NMFS 2009 Opinion (National Marine Fisheries Service 2009b), genetic testing of American River *O. mykiss* population was completed in 2014 to inform the planning for Nimbus Fish Hatchery broodstock replacement that will support the CCV steelhead DPS (National Marine Fisheries Service 2016b).

CCV steelhead returns to Coleman National Fish Hatchery increased from 2011 to 2015. After reaching a low of only 790 fish in 2010, the years 2013 to 2015 averaged 2,854 fish. Natural-origin adults counted at the hatchery each year represent a small fraction of overall returns, but their numbers have remained relatively steady, typically 200 to 300 fish each year, ranging from 252 to 610 from 2010 to 2017, respectively.

An estimated 100,000 to 300,000 naturally-produced juvenile steelhead leave the Central Valley annually, based on rough calculations from sporadic catches in trawl gear (Good et al. 2005; Nobriga and Cadrett 2001) used the ratio of adipose fin-clipped (hatchery) to unclipped (natural-origin) steelhead smolt catch ratios in the Chipps Island trawl from 1998 through 2000 to estimate that about 400,000 to 700,000 steelhead smolts are produced naturally each year in the Central Valley. Updated through 2017, the trawl data indicate that the level of natural production of steelhead has remained very low since the 2011 status review (National Marine Fisheries Service 2011b), suggesting a decline in natural production based on consistent hatchery releases. Catches of steelhead at the fish collection facilities in the southern Delta are another source of information on the relative abundance of the CCV steelhead DPS as well as the production of natural-origin steelhead relative to hatchery steelhead (California Department of Fish and Wildlife 2017c). The overall catch of steelhead has declined dramatically since the early 2000s, with an overall average of 2,795 from 2004 to 2017, as measured by expanded salvage. The percentage of natural-origin (unclipped) fish in salvage has fluctuated, but has leveled off to an average of 34 percent since a high of 93 percent in 1999.

Hatchery production and returns are dominant over natural-origin fish. Continued decline in the ratio between naturally-produced juvenile steelhead to hatchery juvenile steelhead in fish monitoring efforts indicates that the wild population abundance is declining. Hatchery releases (100 percent adipose fin-clipped fish since 1998) have remained relatively constant over the past decade, yet the proportion of adipose fin-clipped hatchery smolts to unclipped naturally produced smolts has steadily increased over the past several years (National Marine Fisheries Service 2016b).

Although CCV steelhead will experience similar effects of climate change to Chinook salmon, as they are also blocked from the vast majority of their historic spawning and rearing habitat, the effects may be even greater in some cases, as juvenile CCV steelhead need to rear in the stream for one to two summers prior to emigrating as smolts. In the Central Valley, summer and fall temperatures below the dams in many streams already exceed the recommended temperatures for optimal growth of juvenile steelhead, which range from 57°F to 66°F (14°C to 19°C). However, one study did find that juvenile steelhead could achieve average growth rates exceeding

1mm/day in the American River even when summer water temperatures regularly exceed 20°C (Sogard et al. 2012). It is unknown if this observation is applicable to steelhead in other Central Valley rivers, but such results from Sogard et al. (2012), and other salmonid-focused studies (Manhard et al. 2018), highlight the interactive role of water temperature and food availability in modulating growth in salmonids. Successful smoltification in steelhead may be impaired by temperatures above 54°F (12°C), as reported in Richter and Kolmes (2005). As stream temperatures warm due to climate change, the growth rates of juvenile steelhead could increase in some systems that are currently relatively cold, but potentially at the expense of decreased survival due to higher metabolic demands and greater presence and activity of predators. Stream temperatures that are currently marginal for spawning and rearing may become too warm to support natural-origin steelhead populations.

One continuing strength of the CCV steelhead DPS is the widespread distribution of this species throughout the rivers of the Central Valley. While most of the measured populations are small, steelhead can be found in most of the major rivers and streams of the Sacramento River, San Joaquin River, and eastside tributaries including the Mokelumne River and Calaveras River. Although there have been recent restoration efforts in the San Joaquin River tributaries, CCV steelhead populations in the San Joaquin Basin continue to show an overall very low abundance, and fluctuating return rates (National Marine Fisheries Service 2016b).

Many watersheds in the Central Valley are experiencing decreased abundance and population growth rates of CCV steelhead. This is largely the result of a significant reduction in the amount and diversity of habitats available to these populations (Lindley et al. 2006), and is likely influenced by changes to the underlying genetic and environmental factors that support the anadromous phenotype of this species (Kendall et al. 2014). Past research has emphasized that genetic makeup (Pearse et al. 2014), growth and survival in freshwater, survival during migration and at sea, and asymptotic sizes achievable in freshwater are likely key factors in determining life-history expression and adaptation (e.g., (Satterthwaite et al. 2009; Satterthwaite et al. 2010). Despite decades of research on this topic, reviewed by Kendall et al. (2014), considerable uncertainty remains regarding the factors that drive the expression of anadromy in *O. mykiss*.

Though genetic analyses conducted over the last twenty years illustrate that there is still significant genetic population structure among steelhead populations within the California Central Valley, they also provide evidence of recent reduction in population size for steelhead throughout the Central Valley (Nielson et al. 2005). Additionally, historical hatchery practices have had a profound influence on the genetic makeup of CCV steelhead. Garza et al. (2008) analyzed the genetic relationships among CCV steelhead populations and found that unlike the situation in coastal California watersheds, fish below barriers in the Central Valley were often more closely related to below barrier fish from other watersheds than to steelhead above barriers in the same watershed. This pattern suggests the ancestral genetic structure is still relatively intact above barriers, but may have been altered below barriers by stock transfers. The genetic diversity of CCV steelhead is also compromised by hatchery-origin fish, which likely comprise the majority of the annual spawning runs, placing the natural-origin population at a high risk of extinction (Lindley et al. 2007). Steelhead in the Central Valley historically consisted of both summer-run and winter-run migratory forms. Only winter-run (ocean-maturing) steelhead are currently found in Central Valley rivers and streams, as summer-run steelhead have been extirpated (McEwan and Jackson 1996; Moyle 2002).

Dam removal and habitat restoration efforts in Clear Creek appear to be benefiting CCV steelhead as recent increases in non-clipped (wild) abundance have been observed. Despite the positive trend in Clear Creek, all other concerns raised in the previous status review remain, including 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. Many other planned restoration and reintroduction efforts have yet to be implemented or completed, or are focused on Chinook salmon, and have yet to yield demonstrable improvements in habitat, let alone documented increases in naturally produced steelhead. There are indications that natural production of steelhead continues to decline and is now at a very low level. Their continued low numbers in most hatcheries, domination by hatchery fish, and relatively sparse monitoring makes the continued existence of naturally reproduced steelhead a concern (National Marine Fisheries Service 2016b).

In summary, all indications are that natural-origin CCV steelhead have continued to decrease in abundance and in the proportion of natural-origin to hatchery-origin fish over the past 25 years (Good et al. 2005; National Marine Fisheries Service 2016b); the long-term trend remains negative. Hatchery-origin production and returns are dominant over natural-origin fish. Most natural-origin CCV steelhead populations are very small and may lack the resiliency to persist for protracted periods if subjected to additional stressors, particularly widespread stressors such as climate change. The genetic diversity of CCV steelhead has likely been impacted by low population sizes and high numbers of hatchery-origin fish relative to natural-origin fish.

The 5-year status review of the CCV steelhead DPS (National Marine Fisheries Service 2016b) found that the status of the DPS appears to have remained unchanged since the 2011 status review (National Marine Fisheries Service 2011b), and the DPS is likely to become endangered within the foreseeable future throughout all or a significant portion of its range.

6.6 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 24). 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 24. Designated critical habitat for California Central Valley steelhead Distinct Population Segment.

The critical habitat for CCV steelhead lists the essential physical and biological features ((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, and

(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 fresh- and saltwater; (ii) natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, 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 basins. Similar to 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. CCV 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 physical and biological features 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 (Good et al. 2005; Jarrett and Killam 2014; National Marine Fisheries Service 2009b; Wright and Schoellhamer 2004). 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 physical and biological features 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 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 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.

6.7 Southern Distinct Population Segment (DPS) of Green Sturgeon

- Listed as threatened ((71 FR 17757); April 7, 2006)
- Designated critical habitat ((74 FR 52300); October 9, 2009)

The federally listed sDPS of North American green sturgeon and its designated critical habitat occur in the action area and may be affected by the proposed action. Although (McElhany et al. 2000) specifically addresses viable populations of salmonids, NMFS believes that the concepts and viability parameters in (McElhany et al. 2000) can be applied to sDPS green sturgeon (see Section 2.2.1).

Green sturgeon are known to range from Baja California to the Bering Sea along the North American continental shelf. During late summer and early fall, subadults and non-spawning adult green sturgeon can frequently be found aggregating in estuaries along the Pacific coast (Emmett et al. 1991; Moser and Lindley 2007). Using polyploid microsatellite data, Israel et al. (2009) found that green sturgeon within the Central Valley of California belong to the sDPS. Additionally, acoustic tagging studies have found that green sturgeon found spawning within the Sacramento River are exclusively sDPS green sturgeon (Lindley et al. 2011). This green sturgeon sDPS structure has also been corroborated by spawning site fidelity (National Marine Fisheries Service 2018f). In waters inland from the Golden Gate Bridge in California, sDPS green sturgeon are known to range through the estuary and Delta and up the Sacramento, Feather, and Yuba rivers (Israel et al. 2009; S.P. Cramer & Associates 2011; Seesholtz et al. 2014). In the Yuba River, sDPS green sturgeon have been documented as far upstream as Daguerre Point Dam (Bergman et al. 2011). Migration past Daguerre Point Dam is not possible for sDPS green sturgeon, although potential spawning habitat upriver does exist. Similarly, sDPS green sturgeon have been observed by DWR staff at the upstream barrier to anadromy on the Feather River (Fish Barrier Dam) and potential spawning habitat also exists upriver of this barrier. On the Sacramento River, Keswick Dam, located at river mile 302, marks the highest point on the river accessible to sDPS green sturgeon, and it might be presumed that sDPS green sturgeon would utilize habitat to this point. However, FWS sampled for larvae in 2012 at river mile 267 and at river mile 292 and no larvae were caught at these locations; habitat usage could not be confirmed any further upriver than the confluence with Ink's Creek (river mile 264), which was a confirmed spawning site in 2011 (Poytress et al. 2012). However, Heublein et al. (2009) detected adults as far upstream as river mile 280 near Cow Creek, suggesting that their spawning range may extend farther upstream than previously documented. The upstream extent of their spawning range lies somewhere below Anderson-Cottonwood Irrigation District 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, however, if sDPS green sturgeon spawning habitat exists in cooler water reaches near Anderson-Cottonwood Irrigation District Dam, which could allow spawning to shift upstream in response to climate change effects.

The sDPS of green sturgeon is composed of a single, independent population, which principally spawns in the mainstem Sacramento River (Israel et al. 2009). The sDPS of green sturgeon exhibits a more complex life history with respect to salmonids and less is known about the ecology and behavior of their various life cycle stages in the action area. Some acoustic telemetry (Chapman et al. 2019; Heublein et al. 2009; Kelly et al. 2007; Steel et al. 2018; Thomas et al. 2019; Thomas et al. 2014; Wyman et al. 2017) and multi-frequency acoustic survey work (Mora et al. 2018) has been done to study adult migration patterns and habitat use in the action area (Delta and Sacramento River).

Field surveys have also been conducted on the Sacramento River to study spatial and temporal occurrence of early life stages (Poytress et al. 2010; Poytress et al. 2011; Poytress et al. 2012; Poytress et al. 2013) (Table 13 and Table 14). These studies have documented some spatial patterns in spawning events on the upper reaches of the Sacramento River. Spawning occurs in cool sections of the upper Sacramento, Feather, and Yuba rivers in deep pools (>16.4 feet) with small to medium sized sand, gravel, cobble, or boulder substrate (National Marine Fisheries Service 2018f). Although Poytress et al. (2015), Seesholtz et al. (2014) and Beccio (2018) observed spawning in the upper Sacramento River, Feather River and Yuba River, respectively, no spawning events have been observed in the lower American River or in the portion of the lower San Joaquin River that is included in the Delta. Recently, an eDNA and video-confirmed green sturgeon was observed in the Stanislaus River occupying a pool downstream of Knights Ferry, CA (river mile 54) (Anderson et al. 2018). Additionally, several lab studies have been conducted using early life stages to investigate ontogenic responses to elevated thermal regimes as well as foraging behavior as a function of substrate type (Allen et al. 2006; Linares-Casenave et al. 2013; Nguyen and Crocker 2006; Poletto et al. 2018). 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 in the action area.

Southern DPS green sturgeon also have been documented in the lower San Joaquin River. Radtke (1966) reported catching green sturgeon in tidal portions of the San Joaquin River at the Santa Clara Shoals. Anglers have also reported catching sDPS green sturgeon at various locations within the San Joaquin River basin upstream of the tidally-influenced Delta. Further, one adult sDPS green sturgeon was confirmed in the Stanislaus River (a tributary to the San Joaquin River) in 2017 (Anderson et al. 2018). With no historical or current evidence of spawning, however, it is believed that sDPS green sturgeon only use the San Joaquin River and its tributaries for rearing.

Table 13. Temporal occurrence of Southern Distinct Population Segment green sturgeon by life-stage at locations in the action area.

Relative Abundance	**High (▼)**						**Medium (⊠)**						**Low (#)**						**None (-)**					
Life-Stage: (a) Adult- sexually mature[1]	Month																							
Location	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
Sac River (river mile 332.5-451)	#	#	#	#	⊠	⊠	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	⊠	⊠	⊠
Sac River (<river mile 332.5)	#	#	#	⊠	⊠	⊠	⊠	⊠	#	#	#	#	#	#	#	#	#	#	#	#	#	#	#	#
Sac-SJ-SF Estuary	#	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	#	#
(b) Larva	Month																							
Location	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
Sac River (<river mile 332.5)	-	-	-	-	-	#	⊠	⊠	▼	▼	▼	▼	▼	▼	⊠	⊠	⊠	⊠	#	#	-	-	-	-
(c) Juvenile (≤5 months old)	Month																							
Location	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
Sac River (<river mile 332.5)	-	-	-	-	-	-	-	#	⊠	⊠	⊠	⊠	▼	▼	▼	▼	▼	▼	▼	⊠	⊠	⊠	⊠	⊠
(d) Juvenile (≤5 months old)	Month																							
Location	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	

Relative Abundance	**High (▼)**						**Medium (☒)**							**Low (#)**					**None (-)**					
Sac River (<river mile 391)	☒	☒	☒	☒	#	#	#	#	#	#	#	☒	☒	☒	☒	▼	▼	▼	▼	▼	▼	▼	▼	#
(e) Sub-Adults and Non-spawning adults	Month																							
Location	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
Sac-SJ-SF Estuary	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	☒	☒
Pacific Coast	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒
Coastal Bays & Estuaries	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	☒	☒

[1] Sexually mature adults (≥4.8 feet TL females, ≥ 3.9 feet TL males including pre- and post- spawning individuals)

Sources: (a) (Heublein et al. 2009); (DuBois and Danos 2018; Klimley et al. 2015a; Mora et al. 2018; Poytress et al. 2015); (b) (Heublein et al. 2017; Poytress et al. 2015); (c) (Heublein et al. 2017; Poytress et al. 2015); (d) (California Department of Fish and Game 2002; Heublein et al. 2017; Poytress et al. 2015; Radtke 1966); (e) (DuBois and Danos 2018; Erickson and Webb 2007; Huff et al. 2011; Lindley et al. 2011; Lindley et al. 2008; Moser and Lindley 2007). Outside of Sac-SJ-SF estuary (e.g. Columbia R., Grays Harbor, Willapa Bay).

Table 14. Temporal occurrence of Southern Distinct Population Segment green sturgeon by life-stage in the Delta.

Relative Abundance	High (▼)	Medium (☒)	Low (#)	None (-)

Life Stage	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult [1]	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒
Juvenile [2]	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒
Salvaged [3]	#	#	#	#	#	-	☒	▼	#	#	#	#

[1]*Adult presence was determined to be year round according to information in (California Department of Fish and Game 2008; California Department of Fish and Game 2009; California Department of Fish and Game 2010a; California Department of Fish and Game 2011; California Department of Fish and Game 2012; California Department of Fish and Wildlife 2013a; California Department of Fish and Wildlife 2014a; Lindley et al. 2008; Moyle 2002).*

[2]*Juvenile presence in the Delta was determined to be year round by using information in (USFWS Delta Juvenile Fish Monitoring Program data), (Moyle et al. 1995; Radtke 1966).*

Adult green sturgeon begin to enter the Bay-Delta in late February and early March during the initiation of their upstream spawning run (Heublein et al. 2009; Moyle et al. 1995). The peak of adult entrance into the Delta appears to occur in late February through early April, with fish arriving upstream of the Glen-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 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. The majority of post-spawn adult green sturgeon will move down river 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. Data on green sturgeon distribution are extremely limited and out-migration appears to be variable occurring at different times of year. Eleven years of recreational fishing catch data for adult green sturgeon (California Department of Fish and Game 2008; California Department of Fish and Game 2009; California Department of Fish and Game 2010a; California Department of Fish and Game 2011; California Department of Fish and Game 2012; California Department of Fish and Wildlife 2013a; California Department of Fish and Wildlife 2014a; California Department of Fish and Wildlife 2015a; California Department of Fish and Wildlife 2016a; California Department of Fish and Wildlife 2017a; DuBois and Danos 2018) show that they are present in the Delta during all months of the year (Figure 25). Although the majority of green sturgeon are expected to be found along the Sacramento River corridor and within the western Delta, observations of 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 Figure 25s. Presence of fish occurs during all seasons of the year, but primarily from fall through spring. Few fish are caught during the summer period.

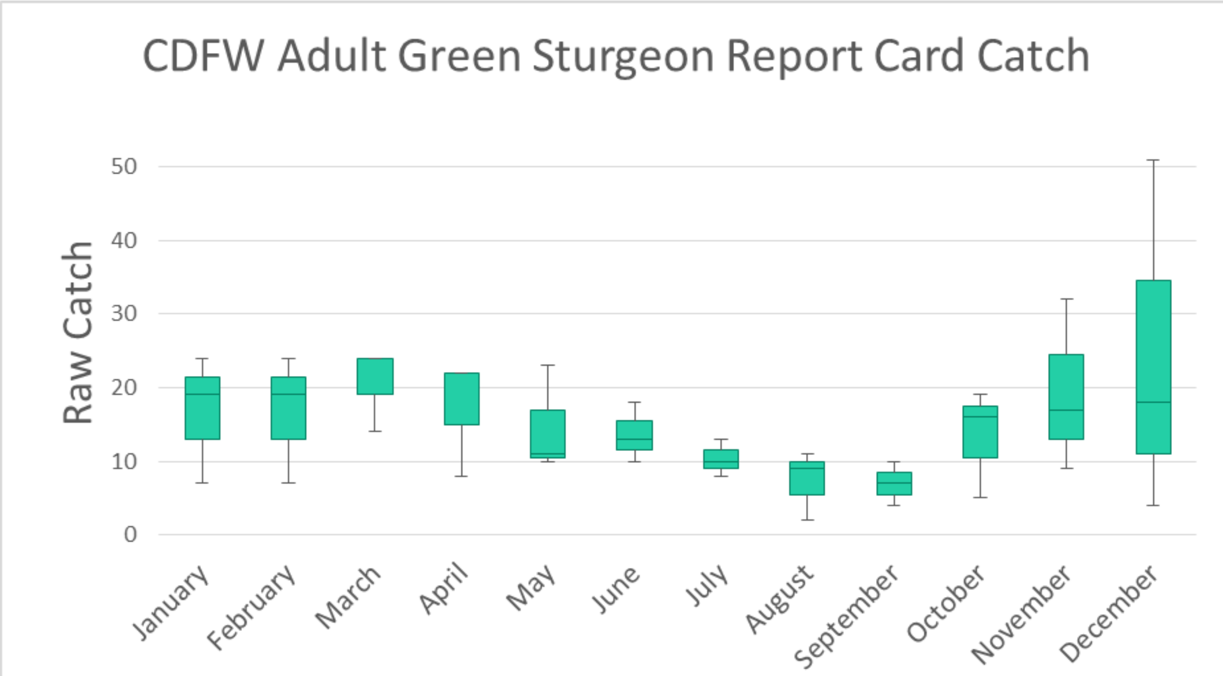


Figure 25. Adult raw catch data for Southern Distinct Population Segement of green sturgeon in the Delta from 2007 to 2014.

Juvenile green sturgeon migrate to the sea when they are 1 to 4 years old (Moyle et al. 1995). Juveniles were collected year round in the Delta during a 1-year study in 1963-1964 (Radtke 1966). The Delta Juvenile Fish Monitoring Program rarely collected juvenile green sturgeon at the seine and trawl monitoring sites. From 1981 to 2012, 7,200 juvenile green sturgeon were reported at the CVP and SWP fish salvage facilities (Figure 26), which indicates a higher presence of juvenile green sturgeon during the spring and summer months in the south Delta where the export facilities are located.

Thomas et al. (2019) found that acoustically tagged juvenile green sturgeon exhibited strong site fidelity to the San Joaquin River channel; all but one animal remained in the channel for the duration of the tracks, which ranged from 16 to 109 hours. Individuals tended to move with tidal currents rather than against them but were also observed to move independent of tidal flow direction. Individuals spent most of their time at or near the bottom of the water column, including areas that had been dredged for navigation. Green sturgeon have adapted to a benthic lifestyle but the results of the study may indicate that juvenile sturgeon may prefer the bottom of the water column where lower water flow rates are likely to be encountered.

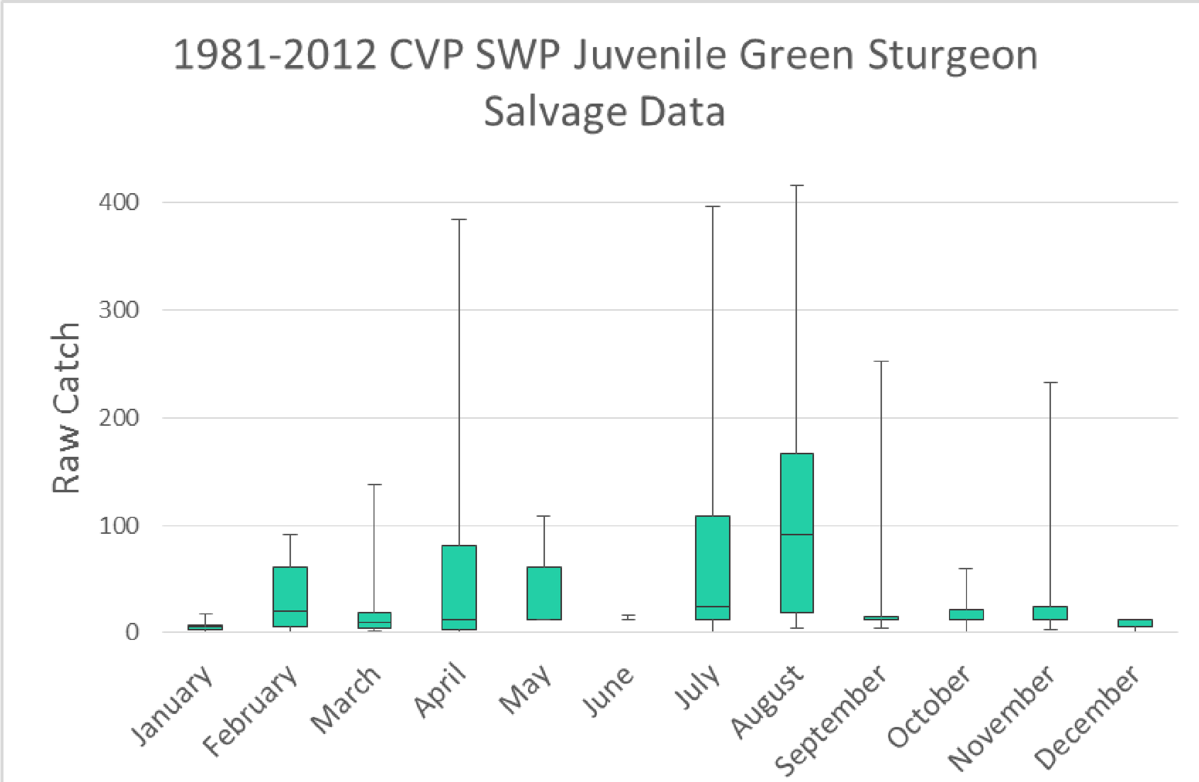


Figure 26. Monthly raw salvage data for juvenile green sturgeon by month at the Central Valley and State Water Project fish salvage facilities (1981 to 2012).

The mainstem Sacramento River and Delta serve as rearing habitat and a migratory corridor for this species. Some rearing also may occur in the lowest reaches of the lower American River where deep pools occur for rearing of older life stages (downstream of SR-160 bridge) (Thomas et al. 2013). CDFW is currently performing a juvenile monitoring study in the Delta using acoustic telemetry (Beccio 2018). Juvenile green sturgeon rear from 1 to 5 years in the Delta and San Francisco Estuary before entering the ocean as sub-adults. Around age 15, mature adults migrate into the San Francisco Estuary in late winter through early spring to spawn in the Sacramento River and its tributaries primarily from April to July, and generally, adults spawn every 3 to 4 years. Elevated Delta outflow is a likely spawning cue for mature adults to enter the river system. Following spawning, adults may remain in the Sacramento River Basin for up to a year; elevated water flows in the late fall and winter signal outmigration in adults that over-summer in spawning habitats (National Marine Fisheries Service 2018f). Information gaps encountered in efforts to summarize information on sDPS green sturgeon life history are often addressed using known information about the Northern DPS.

The historical spawning range of sDPS green sturgeon is not well known, though they are thought to have spawned in many of the major tributaries of the Sacramento River basin, many of which are isolated due to passage impediments (Beamesderfer et al. 2004). Adams et al. (2007) summarizes information that suggests sDPS green sturgeon may have been distributed above the locations of present-day dams on the Sacramento and Feather rivers. Mora et al. (2009) analyzed and characterized known sDPS green sturgeon habitat and used that characterization to identify historic sDPS green sturgeon habitat within the Sacramento River and San Joaquin River basins that are currently blocked by dams. This study concluded that about nine percent of historically available habitat now blocked by impassible dams, was likely of high quality for spawning.

Green sturgeon utilize the lower Sacramento River for spawning and are known to spawn in its upper reaches between Red Bluff Diversion Dam and Keswick Dam (Poytress et al. 2015). Similar to the listed salmonid species addressed in this Opinion, physical and biological features related to spawning and egg incubation have been degraded as discussed in Section 2.2.8. Changes in flow regimes and the installation of Keswick and Shasta dams have significantly reduced the recruitment of spawning gravel in the upper reaches of the lower Sacramento River. Water flow in the Sacramento River have also been significantly altered from their historical condition. The degree to which these altered flow regimes affects outmigration dynamics of juveniles is unknown. Some suitable habitat exists and spawning events have been consistently observed annually (Poytress et al. 2015).

Trends in abundance of sDPS green sturgeon have been estimated from two long-term data sources: (1) salvage numbers at the State and Federal pumping facilities, and (2) incidental catch of green sturgeon by the CDFW's white sturgeon sampling/tagging program. Historical estimates from these sources are expected to be unreliable, as sDPS green sturgeon were likely not taken into account in incidental catch data, and salvage does not capture range-wide abundance in all water year types. Recently, more rigorous scientific inquiry has been undertaken to generate abundance estimates (Israel and May 2010; Mora et al. 2018). A decrease in sDPS green sturgeon abundance has been inferred from the amount of take observed at the south Delta pumping facilities: the Skinner Fish Protective Facility and the Tracy Fish Collection Facility. The salvage data likely indicate a high production year versus a low production year qualitatively, but cannot be used to rigorously quantify abundance.

Since 2010, more robust estimates of sDPS green sturgeon have been generated. As part of a doctoral thesis at U.C. Davis, Ethan Mora has been using acoustic telemetry as well as Dual-frequency identification sonar (DIDSON) to locate green sturgeon in the Sacramento River and to derive an adult spawner abundance estimate (Mora et al. 2018). Results of these surveys estimate an average annual spawning run of 223 (DIDSON) and 236 (telemetry) fish. These surveys have recently been used to generate an adult sDPS green sturgeon abundance estimate of 2,106 (95 percent confidence interval [CI] = 1,246 –2,966; (Mora et al. 2018)). Mora et al. (2018) applied a conceptual demographic structure to the above adult population estimate and generated a subadult sDPS green sturgeon population estimate of 11,055 (95 percent CI = 6,540 – 15,571). These estimates do not include the number of spawning adults in the lower Feather or Yuba rivers, where green sturgeon spawning was recently confirmed (Seesholtz et al. 2014).

The parameters of 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-90s at Red Bluff Diversion Dam and near the Glen Colusa Irrigation District diversion show enormous variability between years. The highest count and density on record was over 30 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 2016). In general, sDPS green sturgeon year class strength appears to be highly variable with overall abundance dependent upon a few successful spawning events (National Marine Fisheries

Service 2010). Other indicators of productivity, such as data for cohort replacement ratios and spawner abundance trends, are not currently available for sDPS green sturgeon.

The sDPS green sturgeon spawn primarily in the Sacramento River from April to July, with the farthest upstream spawning event in the Sacramento River documented near Ink's Creek at river mile 264 (Poytress et al. 2015). The Anderson-Cottonwood Irrigation District Diversion Dam is considered the upriver extent of sDPS green sturgeon migration in the Sacramento River ((71 FR 17757); April 7, 2006). The upriver extent of sDPS green sturgeon spawning, however, is approximately 18.6 miles downriver of the Anderson-Cottonwood Irrigation District Dam because water temperatures in this section of the river are too cold for spawning. Thus, if water temperatures increase with climate change, temperatures adjacent to the Anderson-Cottonwood Irrigation District Dam may remain within tolerable levels for the embryonic and larval life stages of green sturgeon, but temperatures at spawning locations lower in the river may be more affected. It is uncertain, however, if green sturgeon spawning habitat exists closer to the Anderson-Cottonwood Irrigation District Dam, which could allow spawning to shift upstream in response to climate change effects. Successful spawning of sDPS green sturgeon in other accessible habitats in the Central Valley (i.e., the Feather River) is limited, in part, by late spring and summer water temperatures (National Marine Fisheries Service 2015a). Similar to salmonids in the Central Valley, sDPS green sturgeon spawning in tributaries to the Sacramento River is likely to be further limited if water temperatures increase and higher elevation habitats remain inaccessible.

Successful spawning of 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 water temperatures and water flow. Similar to salmonids in the Central Valley, 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. In a bioenergetics study, 59-66°F was the optimal thermal range for age-0 green sturgeon (Mayfield and Cech 2004). If temperatures in spawning habitat exceed that range in the future, it may reduce the fitness of early life stages.

Mora (2016a) demonstrated that sDPS green sturgeon spawning sites are concentrated into very few locations, finding that in the Sacramento River just three sites accounted for over 50 percent of the sDPS green sturgeon spawning activity documented in June of 2010, 2011, and 2012. This is a critical point with regards to the application of the spatial structure VSP parameter, which is largely concerned with the spawning habitat spatial structure, as well as other life history stages. A high concentration of individuals in just a few spawning sites, is more vulnerable to increased extinction risk due to stochastic events.

The sDPS green sturgeon recovery plan (National Marine Fisheries Service 2018f) describes criteria for determining sDPS green sturgeon population recovery and alleviation of threats. Demographic recovery criteria are population metrics that if achieved demonstrate population recovery and alleviation of threats. Threat-based recovery criteria involve actions that would result in population recovery and are as follows:

- Access to spawning habitat is improved through barrier removal or modification in the Sacramento, Feather, and/or Yuba rivers such that successful spawning occurs annually in at least two rivers.
- Volitional passage is provided for adult green sturgeon through the Yolo and Sutter bypasses.

- Water temperature and flows are provided in spawning habitat such that juvenile recruitment is documented annually.
- Adult contaminant levels are below levels that are identified as limiting population maintenance and growth.
- Operation guidelines and/or fish screens are applied to water diversions in mainstem Sacramento, Feather, and Yuba rivers and San Francisco Bay Delta Estuary such that early life stage entrainment is below a level that limits juvenile recruitment.
- Take of adults and subadults through poaching and state, federal and tribal fisheries is minimal and does not limit population persistence and growth.

The viability of sDPS green sturgeon is constrained by factors including a small population size, lack of multiple populations, and concentration of spawning sites into few locations. The risk of extinction is believed to be moderate (National Marine Fisheries Service 2010). Although threats due to habitat alteration are thought to be high and indirect evidence suggests a decline in abundance, there is much uncertainty regarding the scope of threats and the viability of population abundance indices (National Marine Fisheries Service 2010). Lindley et al. (2008), in discussing winter-run Chinook salmon, states that an ESU represented by a single population at moderate risk of extinction is at high risk of extinction over a large timescale; this would apply to green sturgeon. The most recent 5-year status review for sDPS green sturgeon found that some threats to the species have been eliminated, such as take from commercial fisheries and removal of some passage barriers (National Marine Fisheries Service 2015a). Since many of the threats cited in the original listing still exist, the threatened status of the DPS is still applicable (National Marine Fisheries Service 2015a).

Overall, NMFS considers the risk of extinction to be moderate because, although threats due to habitat alteration are thought to be high and the number of spawning adults is relatively low, the scope of threats and the accuracy of the population abundance estimates are uncertain (National Marine Fisheries Service 2018f). However, the sDPS does not meet the definition of viable 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. Additional information about sDPS green sturgeon will be critical to understanding the management needs for this species, especially with regard to robust abundance estimates and the characteristics and distribution of suitable habitats.

6.8 Designated Critical Habitat for Southern Distint 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 mile46

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 27 and Figure 28).

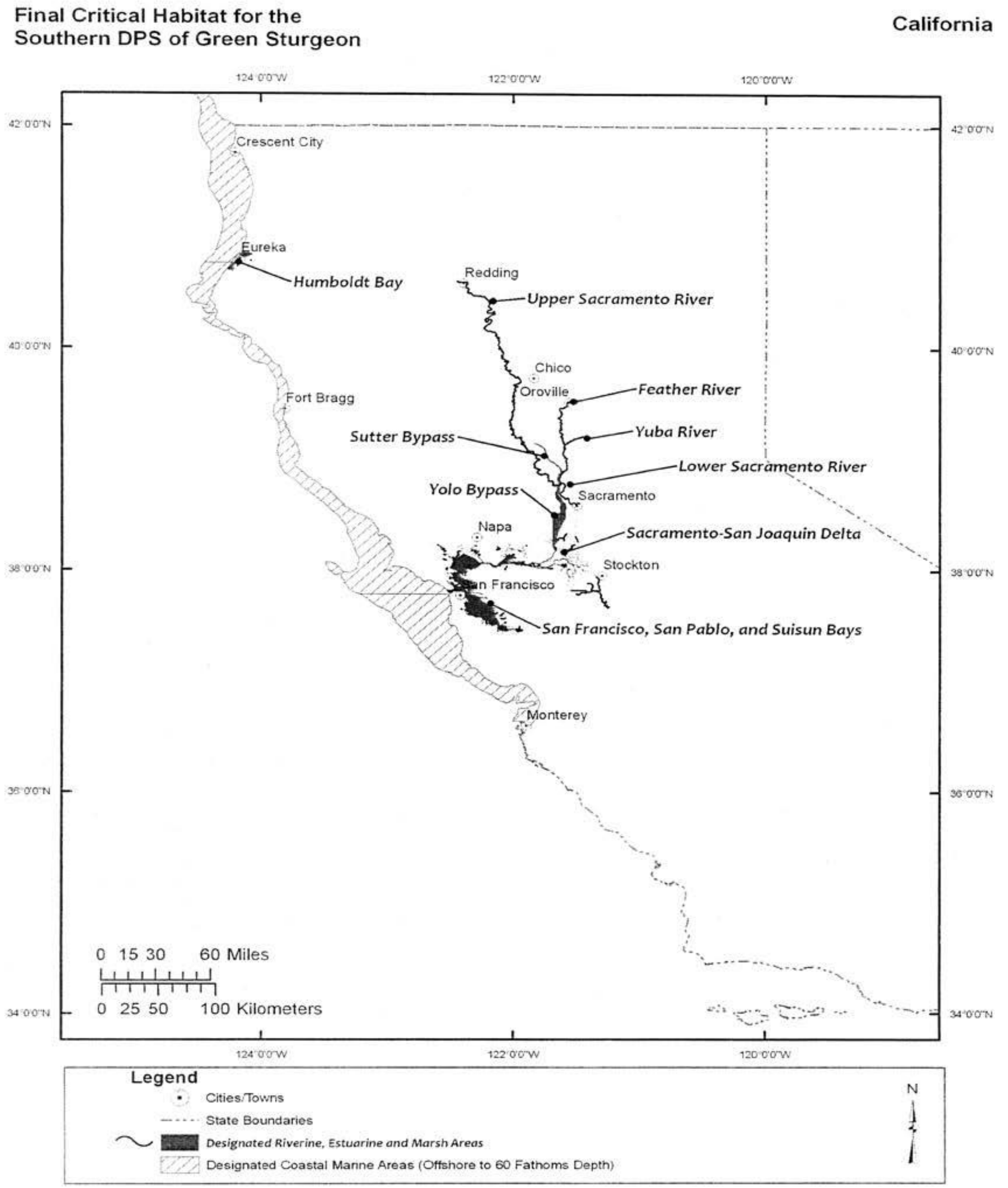


Figure 27. Designated critical habitat for Southern Distinct Population Segment Green sturgeon in California (74 FR 52300).

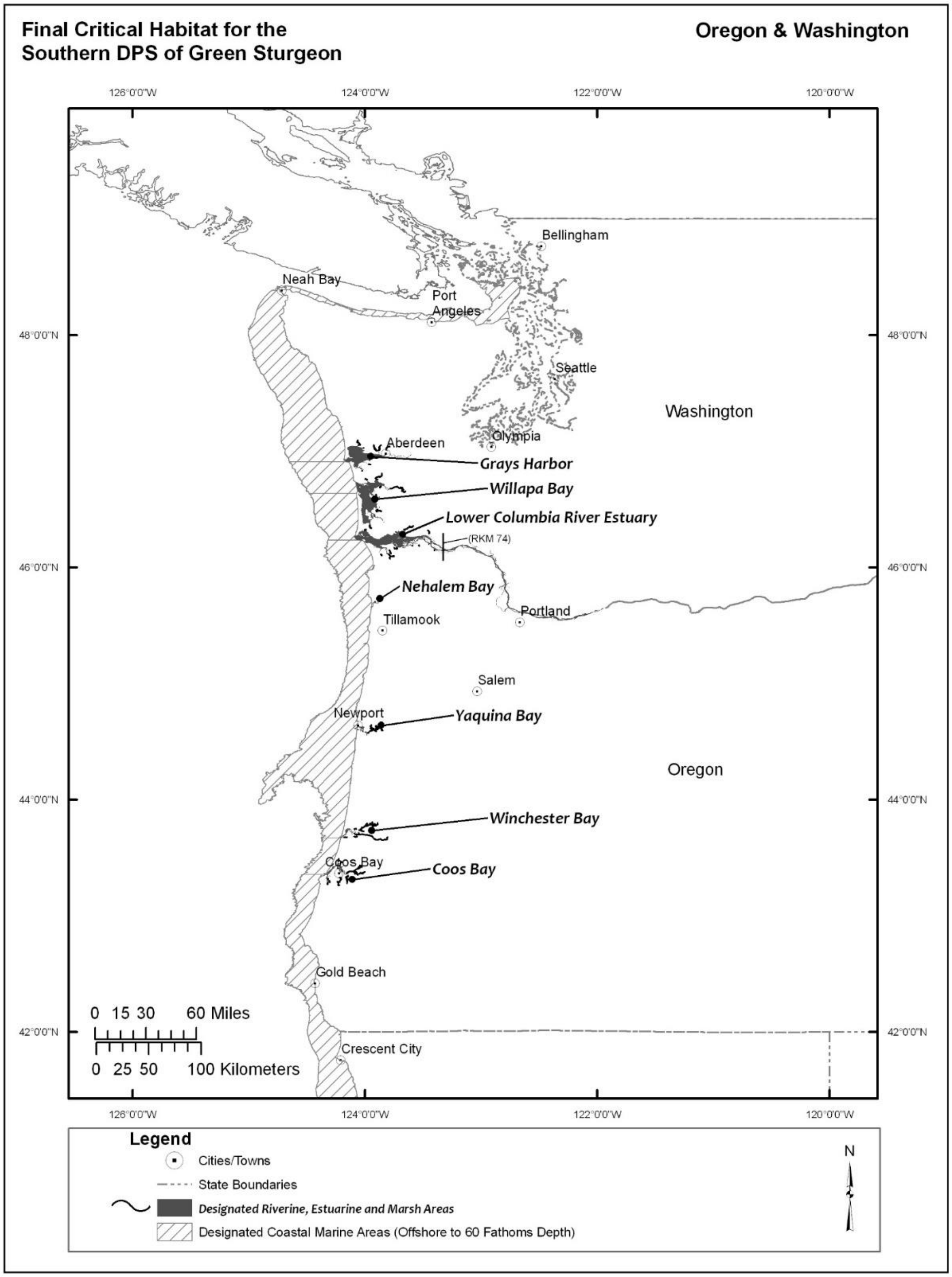


Figure 28. Designated critical habitat for Southern Distinct Population Segment Green sturgeon in Oregon and Washington.

The designated critical habitat for sDPS green sturgeon lists the essential physical and biological features ((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; 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 (National Marine Fisheries Service 2015a; Radtke 1966). Loss of riparian habitat complexity in the Sacramento River and Delta has likely posed less of a threat to green sturgeon because these life stages are benthically oriented. However, it is likely that reverse flows generated by Delta water exports affect the 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 2018a).

Currently, many of the physical and biological features 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 screen diversions, altered flows in the Delta, and presence of contaminants in sediment. Although the current conditions of 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.

6.9 Southern Resident Killer Whale

- Listed as endangered ((70 FR 69903); November 18, 2005)
- Designated critical habitat ((71 FR 69054); November 29, 2006)

The Federally listed Southern Resident killer whale (SRKW) DPS occurs in the action area and may be affected by the proposed action. For purposes of SRKW DPS, the action area includes nearshore coastal areas of California, Oregon, and Washington where SRKW would encounter adult CV Chinook salmon as potential prey. This area does not include Puget Sound or the Strait of Juan de Fuca because the abundance of CV Chinook salmon is extremely low in these areas relative to other stocks present while SRKWs are feeding. Any change in CV Chinook salmon abundance due to the proposed action would therefore have an immeasurably small effect on the total Chinook salmon available to SRKW as prey in the Strait of Juan de Fuca or Puget Sound. Please refer to Southern Resident Killer Whale Recovery Plan (National Marine Fisheries Service 2008b) and the most recent 5-year status review (National Marine Fisheries Service 2016f) for more detailed information on the state of knowledge about the status of SRKW and overall threats that are currently facing the species.

SRKW occur throughout the coastal waters off Washington, Oregon, and Vancouver Island and are known to travel as far south as central California and as far north as Southeast Alaska (Carretta et al. 2017; Hanson et al. 2013; National Marine Fisheries Service 2008b). Three pods – J, K, and L – make up the SRKW population. 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; Hauser et al. 2007; Krahn et al. 2002). In general, the three pods are increasingly present in May and June and spend a considerable amount of time in inland waters through September. Sightings in late fall decline as the whales shift to the outer coastal waters. Satellite-linked tag deployments have provided data on the SRKW movements in the winter indicating that K and L pods use the coastal waters along Washington, Oregon, and California during non-summer months. The limited range of the sightings or acoustic detections of J pod in coastal waters, the lack of coincident occurrence during the K and L pod sightings, and the results from satellite tagging in 2012 to 2016 (NWFSC unpublished data) indicate J pod's limited occurrence along the outer coast and extensive occurrence in inland waters (Figure 29).

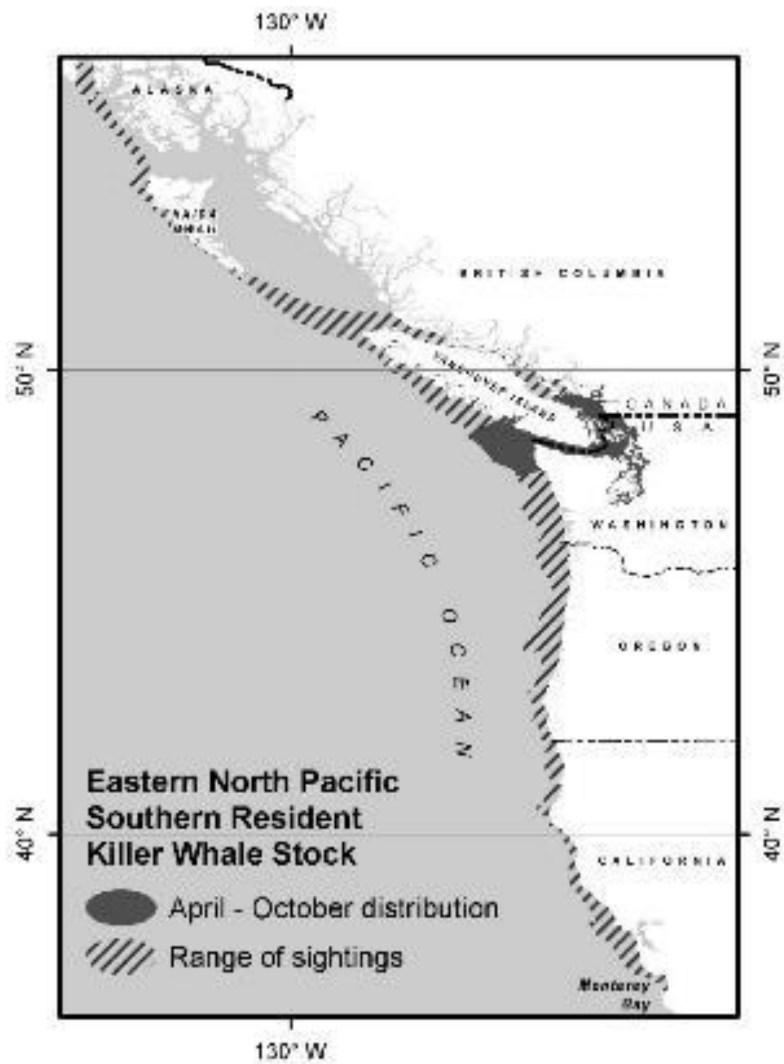


Figure 29. Geographic range of Southern Resident killer whales (reprinted from Carretta et al. 2017).

6.9.1 Population Abundance

The historical abundance of SRKW is estimated from a low population level of 140 animals to an unknown upper bound. The minimum historical estimate (~140) included whales killed or removed for public display in the 1960s and 1970s, which were added to the remaining population at the time the captures ended (National Marine Fisheries Service 2008b). Several lines of evidence (i.e., known kills and removals (Olesiuk et al. 1990), salmon declines (Krahn et al. 2002), and genetics (Ford et al. 2011; Krahn et al. 2002) all indicate that the population used to be much larger than it is now, but there is currently no reliable estimate of the upper bound of the historical population size. Over the last 5 decades, the SRKW population has remained at a similarly low population size fluctuating from about 80-90 individuals (Center for Whale Research (CWR) 2008; Olesiuk et al. 1990).

At present, the SRKW population has declined to the lowest levels seen in over thirty years. During an international science panel review of the effects of salmon fisheries (Hilborn et al. 2012), the panel stated that during 1974 to 2011, the population experienced a realized growth rate of 0.71 percent, from 67 individuals to 87 individuals. NMFS has continued to fund the Center for Whale Research (CWR) to conduct an annual census of the SRKW population. As of December 2018, the population had decreased to only 74 whales, a historical low in the last 30 years with a current realized growth rate (from 1974 to 2017) at half of the previous estimate described in the science panel report; 0.29 percent. Recent estimates based on a July 2019 survey indicate Southern Residents now total approximately 73 individuals: 22 in J pod, 17 in K pod, and 34 in L pod (Center for Whale Research 2019).

Seasonal mortality rates among SRKW may be highest during the winter and early spring, based on the numbers of animals missing from pods returning to inland waters each spring. Olesiuk et al. (2005) identified high neonate mortality that occurred outside of the summer season. Additionally, stranding rates are higher in winter and spring for all killer whale forms in Washington and Oregon (Norman et al. 2004).

6.9.2 Impact of Prey Species

Significant attention has been paid in recent years to the relationship between the Southern Resident population and the abundance of important prey, especially Chinook salmon. NMFS has previously consulted on the effects of the long-term operations of the CVP and SWP in California (National Marine Fisheries Service 2009a). In that analysis, NMFS found that the long-term operations of the CVP and SWP, as proposed, were likely to jeopardize the continued existence of several ESA-listed Chinook salmon ESUs. NMFS concluded that the increased risk of extinction of the winter- and spring-run Chinook salmon, along with loss of diversity in fall-run, as a long-term consequence of the proposed action was likely to reduce the likelihood of survival and recovery of the SRKW DPS, although implementation of the 2009 RPA actions for reducing adverse impacts to Chinook salmon was also determined sufficient to reduce adverse impacts on SRKW and avoid jeopardy. The relationship of the proposed action analyzed in this Opinion to the 2009 RPA, and how the proposed action addresses key impacts avoided, minimized, or offset by the 2009 RPA actions is described in further detail in the Introduction (Section 1.4.5).

In general, the factors affecting non-listed Chinook salmon (fall-run and late fall-run) in the freshwater environment in the Central Valley are identical or very similar to what is discussed for ESA-listed Chinook salmon. All of these important influences on Chinook salmon in the freshwater environment contribute to the health, productivity, and abundance of Chinook salmon that ultimately survive to reach the ocean environment and influence the prey base and health of SRKW. Currently, there is no capability to generate specific estimates of the number of Chinook salmon that may be found in the ocean within any defined boundary that would include likely or possible coastal migrations of SRKW during the winter and spring. There are many different management and monitoring schemes that are employed for Chinook salmon along the western North American coast that make it difficult to directly relate and compare metrics of Chinook salmon abundance. A commonly used approach involves use of relative indexes as opposed to absolute measures of abundance, such as the WCVI index that has been previously related to Southern Resident population dynamics (Ward et al. 2013). In addition, many of the estimates or forecasts of Chinook salmon abundance used for management are related to escapements that are not inclusive of adult Chinook salmon that remain in the ocean to mature, or succumb to predation or other forms of mortality. In combination, use of catch and escapement data from Chinook salmon populations that occur in the range of SRKW could provide some minimum measure of the absolute abundance of Chinook salmon that are available, although all of these Chinook salmon individuals would not necessarily always overlap with SRKW during any specific time period given the uncertain and variable migratory nature of Chinook salmon and Southern Residents. Without any comprehensive and consistent monitoring and assessment methodology across Chinook salmon populations throughout the range of SRKW, we will combine the data and information that are available for use in generally characterizing the abundance of coast-wide Chinook salmon potentially available to SRKW, as well as the relative importance of Central Valley Chinook salmon to that total.

In general, ocean abundance estimates for Chinook salmon that originate from U.S. systems are provided by the Pacific Fisheries Management Council (Pacific Fishery Management Council 2019). The estimated 2019 ocean abundance of Sacramento River fall-run Chinook salmon (Sacramento Index), which constitutes most of the Chinook salmon that are harvested in the ocean or return to the Central Valley in terms of abundance, is 379,600 fish (Pacific Fishery Management Council 2019)[5]. Winter, spring, and late fall-run Chinook salmon are not included in the Sacramento Index. These runs combined collectively constitute approximately ten percent of all Central Valley Chinook salmon returns on average; ranging from 5-27 percent of Central Valley Chinook salmon returns over the last two decades (California Department of Fish and Wildlife 2019a). Since the early 1980s, Sacramento Index values commonly range from 500,000 to 1 million fish, although recent abundances have been much smaller than historical averages, and Sacramento Index values have exceeded 300,000 only three times in the last 12 years (Pacific Fishery Management Council 2019). In 2019, the Klamath River was estimated to have an ocean abundance of 274,000 fish; which is generally consistent with the average ocean abundance of Klamath over the last ten years (Pacific Fishery Management Council 2019). Including escapement forecasts for Columbia River Chinook salmon stocks (514,400 fish) with other stocks south of the Strait of Juan de Fuca (48,800 fish); along with Puget Sound, Hood Canal, and the Strait of Juan de Fuca combined (243,800 fish); the total Chinook salmon abundance from these sources equals 1,460,800 fish in 2019 (Pacific Fishery Management

[5] The Sacramento Index is limited to a measure of catch and escapement abundance, and not absolute abundance in the ocean. The Sacramento Index index is the sum of (1) adult Sacramento River Fall Chinook (SRFC) salmon ocean fishery harvest south of Cape Falcon, OR (2) adult SRFC impacts from non-retention ocean fisheries when they occur, (3) the recreational harvest of adult SRFC in the Sacramento River Basin, and (4) the SRFC adult spawner escapement. The Sacramento Index forecasting approach uses jack escapement estimates to predict the Sacramento Index Pacific Fishery Management Council. 2019. Review of 2018 Ocean Salmon Fisheries Stock Assessment and Fishery Evaluation Document for the Pacific Coast Salmon Fishery Management Plan..

Council 2019), of which 379,600/1,460,800=26 percent originate from the Central Valley. As mentioned, 2019 is expected to be a relatively low abundance year compared to the period between 1979 and 2018 for Sacramento River fall-run Chinook salmon based on the Sacramento Index forecast, which historically would be more significant to the overall abundance especially in the action area.

While the estimated proportion of Chinook salmon originating from the Central Valley for 2019 does include accounting of most of the significant populations of Chinook salmon along the U.S. coast, this does not include any totals from significant Canadian Chinook salmon populations that are likely encountered by SRKW to some degree, in particular Fraser River and West Coast Vancouver Island stocks. Although abundance estimates or escapement forecasts for 2019 are not readily available for these Chinook salmon stocks (largely managed through relative abundance indices), it is possible to look at historical catch and escapement numbers to get a sense of at least the minimum number of these fish that are in the ocean in the range of SRKW at some point each year. During the independent science panel, historical estimates of catch and escapement for most all major Chinook salmon stocks from British Columbia to California were produced (Kope and Parken 2011). Across all major Chinook salmon populations, Kope and Parken (2011) reported that the total number of Chinook salmon that were either captured or escaped annually from 1979-2010 ranged from about two to six million; commonly between three and four million fish. Although these totals are certainly an underestimate of all the Chinook salmon that could be present in coastal waters along the west coast associated with these populations, and the precise overlap of SRKW with all these populations at all times during the year is not well established, we conclude based on the historical catch and escapement data presented above that the relative magnitude of Chinook salmon in the range of SRKW each year is likely at least several million fish. Based on the tabulations of catch and escapement conducted by Kope and Parken (2011), we can get a sense of the relative contribution of Central Valley Chinook salmon (as represented by the Sacramento Index) to the total abundance of Chinook salmon in the range of SRKW. On average since the early 1980s, it appears that the Sacramento Index constitutes about 20 percent of the total catch and escapement of all these Chinook salmon populations that are likely encountered by SRKW to some degree, although this proportion varies from about 10-30 percent each year depending on varying strengths in run size (Kope and Parken 2011).

Largely, our knowledge of the distribution of Central Valley Chinook salmon in the ocean comes from the data obtained from coded wire tags and genetic stock information obtained from fish harvested in ocean fisheries that generally occur sometime between April and October. Unfortunately, the timing of ocean salmon fisheries does not overlap well with the occurrence of SRKW in coastal waters during the winter and spring, and has not especially in the last few decades. Ocean distribution of Chinook salmon populations based on summer time fishery interactions generally indicates northern movements of Chinook salmon from their spawning origins (Weitkamp 2010), although the range of these movements is quite variable between populations and run timings, and the distribution of Chinook salmon populations in the winter and spring when SRKW are likely to encounter Central Valley Chinook salmon stocks is not as well known. Recently, Shelton et al. (2019) estimated the seasonal ocean distribution, survivorship, and aggregate abundance of fall-run Chinook salmon stocks from California to British Columbia. While their analysis did not appear to reveal significant seasonal variance in the relative distribution of Chinook salmon stocks from California during the winter and spring compared to the summer and fall, they generally concluded that fall-run Chinook salmon stocks tended to be more northerly distributed in summer than in winter-spring, and ocean distributions also tend to be spatially less concentrated in the winter-spring (Shelton et al. 2019). Without any additional information available that would suggest the distribution of Central Valley Chinook salmon shifts substantially during the winter or spring, we assume the distribution of Central Valley Chinook salmon during the winter and spring is similar to what has been documented during the summer and fall, and that data collected from hatchery fish (usually where CWTs are applied) are representative of the distribution of both naturally produced and hatchery-origin fish.

The available data from CWT and genetic stock information confirm that Chinook salmon from the Central Valley (particularly fall-run) occur in small numbers as far north as Vancouver Island, British Columbia, but are primarily encountered by ocean salmon fisheries south of the Columbia River (Bellinger et al. 2015; Shelton et al. 2019; Weitkamp 2010). Central Valley Chinook salmon (primarily fall-run) constituted sizeable proportions of Chinook salmon sampled off the coast of Oregon and California during the 2010 fishing season where comprehensive genetic stock information data were collected (Bellinger et al. 2015).[6]

In total, the available data suggest that Central Valley Chinook salmon constitute a sizeable percentage of Chinook salmon that would be expected to be encountered by SRKW in coastal waters off California and Oregon, and at least a small portion of Chinook salmon in the ocean as far north as British Columbia. In addition, ratios of contaminants in blubber biopsies found that the blubber of K and L pod match with similar ratios of contaminants in Chinook salmon from California, which was indicated by the relatively high concentrations of dichlorodiphenyltrichloroethane (DDT). These DDT fingerprints suggest fish from California[7] form a notable component of their diet, at least during certain times of the year (Krahn et al. 2007; Krahn et al. 2009; O'Neill et al. 2012). As a result, we conclude that Central Valley Chinook salmon make up a significant portion of the total abundance of Chinook salmon available to SRKW throughout their range in most if not all years; likely at least several hundred thousand individual fish other than during years of exceptionally low abundance for Central Valley Chinook salmon. In addition, the known distributions of Chinook salmon along the coast suggest that Central Valley Chinook salmon are an increasingly significant prey source (as SRKW move south along the U.S. West Coast) during any southerly movements of SRKW along the coast of Oregon and California that may occur during the winter and spring (Bellinger et al. 2015; Shelton et al. 2019; Weitkamp 2010).

Recently, Ford et al. (2016) confirmed the importance of Chinook salmon to SRKW in the summer months using DNA sequencing from whale feces. The researchers found that salmonids made up to over 98 percent of the whales inferred diet, of which almost 80 percent were Chinook salmon. Researchers also found evidence of prey shifting at the end of summer towards coho salmon for all years analyzed; coho salmon contributed to over 40 percent of the diet in late

[6] Bellinger et al. (2015) estimated that Central Valley Chinook salmon made up about 22% of the Chinook salmon sampled off the Oregon coast and about 50% of those sampled off the California coast (south to Big Sur) during that one-year study. 2010 was a very low year for Central Valley harvest and escapement (ibid).

[7] The research does not specify if or how much fish from the Central Valley specifically contribute to the diet: only that SRKW must feed in areas where Chinook with California origins occur. Consistent with the information reviewed, Central Valley Chinook salmon overlap in space and time with Chinook from other California origins like the Klamath River (Shelton et al. 2019).

summer. Chum, sockeye, and steelhead made up relatively small contributions to the sequences (less than 3 percent each). Although less is known about the diet of SRKW off the Pacific coast during winter, the available information from observation of predation events indicates that salmon, and Chinook salmon in particular, are also important when the whales occur in coastal waters (Hanson et al. 2010).

One hypothesis as to why killer whales primarily consume Chinook salmon even when they are not the most abundant salmon available is because of the Chinook salmon's relatively high energy content (Ford and Ellis 2006). Chinook salmon have the highest value of total energy content compared to other salmonids because of their larger body size and higher energy density (expressed in kcal/kg) (O'Neill et al. 2014). For example, in order for a killer whale to obtain the total energy value of one average size adult Chinook salmon, it would need to consume approximately 2.7 averaged size coho salmon, 3.1 chum salmon, 3.1 sockeye salmon, or 6.4 pink salmon (O'Neill et al. 2014).

Studies have evaluated 25 years of demographic data from Southern and Northern Resident killer whales and found that changes in survival largely drive their population, and the populations' survival rates were strongly correlated with coast-wide availability of Chinook salmon (Ford et al. 2010; Ford et al. 2005). Ward et al. (2009) found that Northern and SRKW fecundity was highly correlated with Chinook salmon abundance indices, and reported the probability of calving increased by 50 percent between low and high Chinook salmon abundance years. More recently, Ward et al. (2013) considered new stock-specific Chinook salmon indices and found strong correlations between the indices of Chinook salmon abundance, such as the West Coast Vancouver Island (WCVI) used by the Pacific Salmon Commission, and killer whale demographic rates. However, no single stock or group of stocks was identified as being most correlated with the whales' demographic rates. Further, they stress that the relative importance of specific stocks to the whales likely changes over time (Ward et al. 2013).

In addition to examining whether any fundamental linkages between vital rates and prey abundance are evident, another primary purpose of many of these analyses has been aimed at distinguishing which Chinook salmon stocks, or grouping of Chinook salmon stocks, may be the most closely related to these vital rates for SRKW. Largely, attempts to compare the relative importance of any specific Chinook salmon stocks or stock groups using the strengths of these statistical relationships have not produced clear distinctions as to which are most influential, as most Chinook salmon stock indices are highly correlated with each other. It is also possible that different populations may be more important in different years. Large aggregations of Chinook salmon stocks that reflect abundance on a coastwide scale appear to be as equally or better correlated with Southern Resident vital rates than any specific or smaller aggregations of Chinook salmon stocks, including those that originate from the Fraser River that have been positively identified as key sources of prey for SRKW during certain times of the year in specific areas (Hilborn et al. 2012; Ward et al. 2013).

However, there are still questions about the diet preferences of SRKW throughout the entire year, as well as the relative exposure of SRKW to various Chinook salmon or other salmon stocks outside of inland waters during the summer and fall. To help answer some of these questions, NMFS and Washington Department of Fish and Wildlife (WDFW) recently released a report to help evaluate and identify which Chinook stocks, including Central Valley Chinook salmon, should be priorities for recovery actions to help increase SRKWs' prey base (National

Marine Fisheries Service and Washington Department of Fish and Wildlife 2018). The report prioritized 30 stocks of Chinook salmon ESUs into seventeen groups based on three factors (1) the stock's observed contribution to diet, (2) degree of spatio-temporal overlap, and (3) whether it would be consumed during a time of killer whale reduced body condition or diversified diet. The Central Valley stocks ranked 13 (spring-run Chinook salmon), 16 (fall and late fall-run Chinook salmon), and 21 (winter-run Chinook salmon).

As referenced above, the independent science panel found good evidence that Chinook salmon are a very important part of the SRKW diet and that some SRKW have been in poor condition recently, which is associated with higher mortality rates. They further found that the data and correlations developed to date provide some support for a cause and effect relationship between salmon abundance and SRKW survival and reproduction. They identified "reasonably strong" evidence that vital rates of SRKW are, to some degree, ultimately affected by broad-scale changes in their primary Chinook salmon prey. They suggested that the effect is likely not linear, however, and that predicted improvements in SRKW survival with increasing abundances of Chinook salmon may not be realistic or may diminish at Chinook salmon abundance levels that are above their historical average (Hilborn et al. 2012). Given all the available information, and considering the uncertainty that has been highlighted, we assume that the overall abundance of Chinook salmon as experienced by foraging SRKW throughout their range may be as influential on their vital rates as any other relationships with any specific Chinook salmon stocks.

6.9.3 Southern Resident Killer Whale Viability

The viability of the SRKW DPS is evaluated through the consideration of the threats identified in the recovery plan and the population status relative to downlisting criteria. Since completing the recovery plan, NMFS has prioritized actions to address the threats with highest potential for mitigation: salmon recovery, oil spill response, and reducing vessel impacts. Several threats criteria have been met, but many will take years of research and dedicated conservation efforts to satisfy. Salmon recovery is a high priority on the West Coast and there are numerous actions underway to address threats to salmon populations and monitor their status. Recovery of depleted salmon populations is a complex, long-term process. NMFS and partners have successfully developed an oil spill response plan for killer whales (National Marine Fisheries Service 2016f). However, we still have additional work to prepare for a major spill event. NMFS has developed special vessel regulations intended to reduce disturbance of killer whales from vessel traffic. It will take time to evaluate the effectiveness of any new regulations in improving conditions for the whales. Even with progress toward minimizing the impacts of the threats, each of the threats still pose a risk to the survival and recovery of the whales (National Marine Fisheries Service 2016f).

Recent updates to population viability analyses suggest a 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). To explore potential demographic projections, Lacy et al. (2017) constructed a population viability assessment that considered sublethal effects and the cumulative impacts of threats (contaminants, acoustic disturbance, and prey abundance). They found that over the range of scenarios tested, the effects of prey abundance on fecundity and survival had the largest impact on the population growth rate. Furthermore, they suggested in order for the population to reach the recovery target of 2.3 percent growth rate, the acoustic disturbance would need to be reduced in half and the Chinook abundance would need to be increased by 15 percent (Lacy et al. 2017).

The health of individual SRKW is being studied closely. As a chronic condition, nutritional stress can lead to reduced body size and condition of individuals, and lower reproductive and survival rates of a population (Trites and Donnelly 2003). Very poor body condition is detectable by a depression behind the blowhole that presents as a “peanut-head” appearance. There have been several SRKW that have been observed in recent years with the “peanut-head” condition, and the majority of these individuals died relatively soon after these observations (Durban et al. 2017; Fearnbach et al. 2018). The bodies of the SRKW that died following these observations were not recovered and therefore a definitive cause of death could not be identified. More recently, photographs of whales from an unmanned aerial system (i.e., a drone) have been collected and individual whales in poor condition have been observed. Both females and males across a range of ages were found in poor body condition.

Killer whales are exposed to persistent pollutants primarily through their diet, including Chinook salmon. These harmful pollutants are stored in blubber and can later be released and become redistributed to other tissues when the whales metabolize the blubber in response to food shortages or reduced acquisition of food energy that could occur for a variety of other reasons including during gestation or lactation. High levels of these pollutants have been measured in blubber biopsy samples from SRKW (Krahn et al. 2007; Krahn et al. 2009; Ross et al. 2000), and more recently these pollutants were measured in scat samples collected from the whales, providing another potential opportunity to evaluate exposure of SRKW to these pollutants (Lundin et al. 2016). High levels of persistent pollutants have the potential to affect the whales’ endocrine and immune systems and reproductive fitness (Krahn et al. 2002). Vessel activities may affect foraging efficiency, communication, and/or energy expenditure through the physical presence of the vessels, underwater sound created by the vessels, or both (National Marine Fisheries Service 2016f). Noise levels killer whales receive are largely determined by the speed of the vessel (Houghton et al. 2015). Thus, to reduce noise exposure to the whales, reduced vessel speeds have been recommended. In 2011, NMFS announced final regulations to protect killer whales in Washington State from the effects of various vessel activities (76 FR 20870).

Several factors identified in the final recovery plan for SRKW may be limiting recovery. These are quantity and quality of prey, toxic chemicals that accumulate in top predators, and disturbance from sound and vessels. When prey is scarce, SRKW likely spend more time foraging than when prey is plentiful. Increased energy expenditure and prey limitation can cause poor body condition and nutritional stress. Nutritional stress is the condition of being unable to acquire adequate energy and nutrients from prey resources and as a chronic condition, can lead to reduced body size of individuals and to lower reproductive and survival rates of a population (Trites and Donnelly 2003). Oil spills are also a risk factor. 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 and available data suggests that all of the threats are potential limiting factors (National Marine Fisheries Service 2008b).

At the time of listing in 2005 there were 88 whales in the population, and by the end of 2016 there were 78 whales. Recent surveys suggest only 73 individuals remain (Center for Whale Research 2019). Population growth has varied during this time with both increasing and decreasing years. The biological downlisting and delisting criteria, including sustained growth over 14 and 28 years, respectively, have not been met (National Marine Fisheries Service 2016f). While some of the biological downlisting and delisting criteria have been met (i.e., representation in all three pods, multiple mature males in each pod), the overall status of the population is not consistent with a healthy, recovered population. Considering the status and continuing threats, the SRKW remain in danger of extinction (National Marine Fisheries Service 2011f).

6.10 Designated Critical Habitat for Southern Resident Killer Whale

Designated critical habitat for the SRKW consists of three specific marine areas of Puget Sound, Washington: (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)(71 FR 69054). These areas are not part of the action area, and are not expected to be affected by the proposed action; therefore, critical habitat for SRKW will not be discussed further in this Opinion.

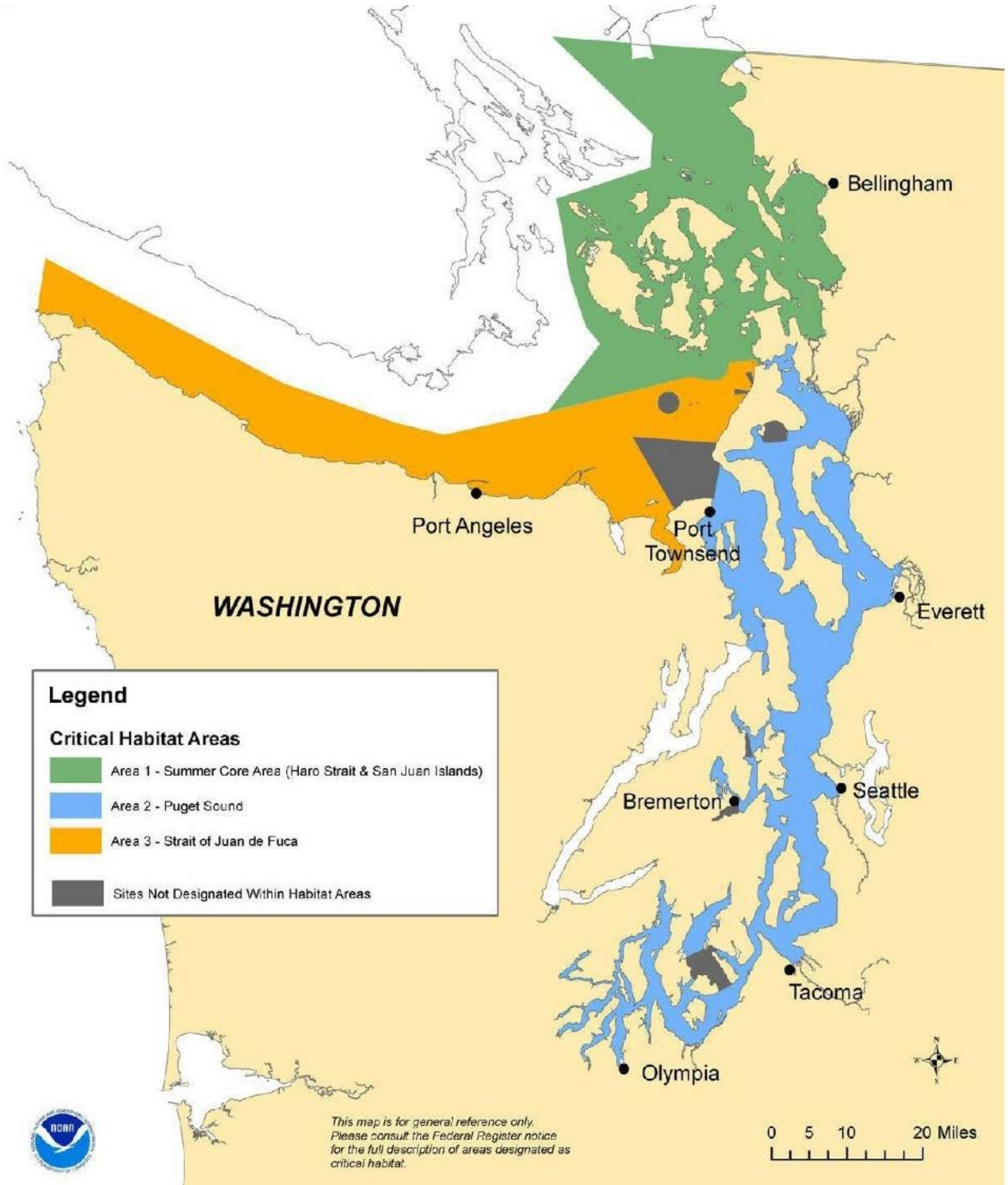


Figure 30. Southern Resident killer whale Distinct Population Segment designated critical habitat.

7 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" (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 (Sobeck 2016), climate change is included 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. As defined by ESA regulations, 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 section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process (50 CFR 402.02) (Figure 31). The key purpose of the environmental baseline is to describe the condition of the listed species/critical habitat in the action area in the absence of the proposed action.

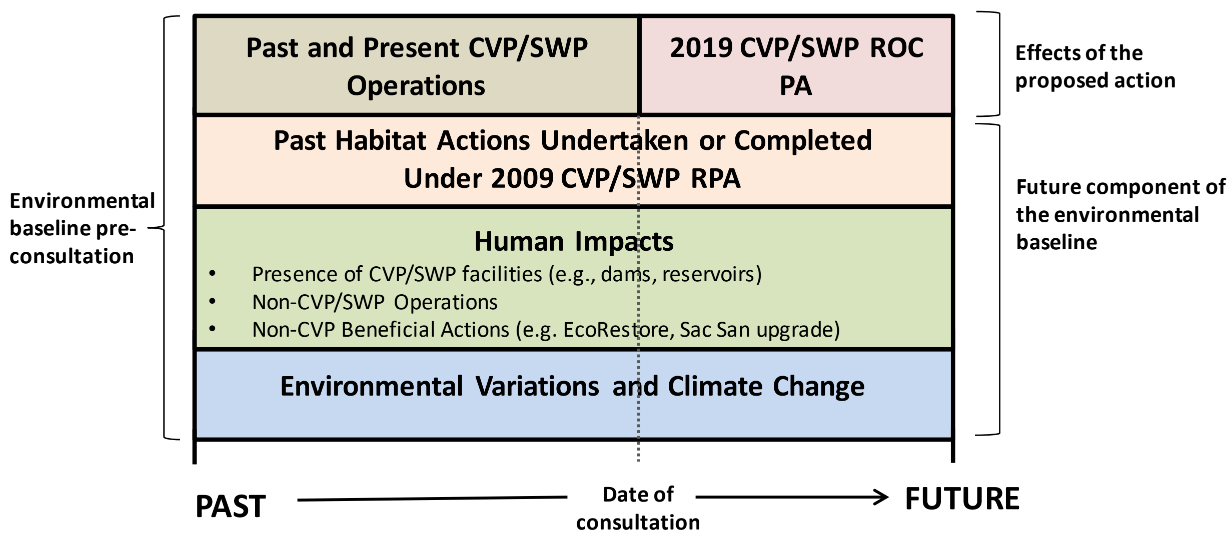


Figure 31. A conceptual model of the effects of the proposed action added on top of the future component of the environmental baseline.

Reclamation created a without action scenario as part of their biological assessment description of the environmental baseline to isolate and define potential effects of the proposed action apart from effects of non-proposed actions. Reclamation presented the environmental baseline without action scenario as "the future 'without-action' condition and the past, present, and ongoing impacts of human and natural factors, including the present and ongoing effects of current operations that were considered in prior consultations." Reclamation's without action scenario entails no future operations of the CVP and SWP. In other words, no active modification of flows through CVP and SWP facilities. As part of the baseline analysis, the without action scenario is a useful analytical tool to separate some of the effects related to the existence of CVP and SWP facilities and provides context for how these facilities have shaped and continue to affect the species and critical habitat in the action area. Specifically, the ROC on LTO biological assessment describes the without action scenario as:

> *"…in a consultation on an ongoing action, the without-action scenario cannot be defined by simply projecting the status quo into the future, because doing so would improperly include in the baseline the continued effects of the action under consultation. Instead, in a consultation on an ongoing action, such as operation of the CVP and SWP, the baseline analysis must project a future condition without the action. This allows for isolation of the effects of the action from the without-action scenario and, in turn, a determination of whether the action is likely to jeopardize listed species and/or destroy or adversely modify critical habitat. Thus, to provide a snapshot of the species' survival and recovery prospects without the proposed action, Reclamation is analyzing a without-action scenario. The without-action scenario entails no future operations of the CVP and SWP: in other words, no discretionary regulation of flows through the system, including, for example, storing and releasing water from reservoirs and delivering water otherwise required by contract."*

The without action modeling representing this scenario did not include CVP and SWP operations, but does included the operations of non-CVP and non-SWP facilities, such as operation of public and private reservoirs on the Yuba, Tuolumne, and Merced rivers. NMFS considers the without action scenario to represent effects related to the existence of CVP and SWP facilities. Through modeling, the ROC on LTO biological assessment, used the without action scenario in order to compare the effects of the proposed action against the without action scenario.

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 section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process (50 CFR 402.02). 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 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 and 2009), the impacts of past and present operations of the CVP and SWP become part of the environmental baseline for subsequent consultations (Figure 31). 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.

The NMFS analysis recognizes 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. NMFS' analysis traces and evaluates the proposed action. With respect to dams, NMFS treats the existence of dams and some past operations as part of the baseline. NMFS considers in the proposed action effects analysis how future daily, monthly and seasonal operational decisions to store or release water from CVP and SWP reservoirs can have effects downstream and through the Delta, in various timescales. Depending on the flow and quality (e.g., temperature) of the water released, the timing and location, and 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 important habitats, or blocked access to them, 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 SRKW on Chinook salmon prey resources that include Central Valley Chinook salmon these factors have also been, 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). Recent 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).

Dams, levees, land conversion, urbanization, water management, and gold mining are the main landscape-scale factors that have shaped 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.

7.1 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 winter-run Chinook salmon, spring-run Chinook salmon, steelhead, and 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) (Cummins et al. 2008; Yoshiyama et al. 2001). 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 steelhead (Lindley et al. 2006). Modeling by Mora et al. (2009) indicates about 9% 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 2018f). The existence of these impassable barriers has significant adverse effects on species in the past, present and future.

Prior to 2012, seasonal closure of RBDD limited sDPS green sturgeon spawning to habitats that were likely unsuitable for egg incubation in some years. With permanent decommissioning of RBDD, 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 (RM 302), remains a potential passage barrier to spawning 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. However, the proportion of sDPS green sturgeon spawning impeded by the ACID Dam may increase with potential spawning habitat expansion, or warmer water releases at Keswick Dam.

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 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 green sturgeon.

7.2 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). 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 (Jeffres et al. 2008; Sommer et al. 2001b), 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.

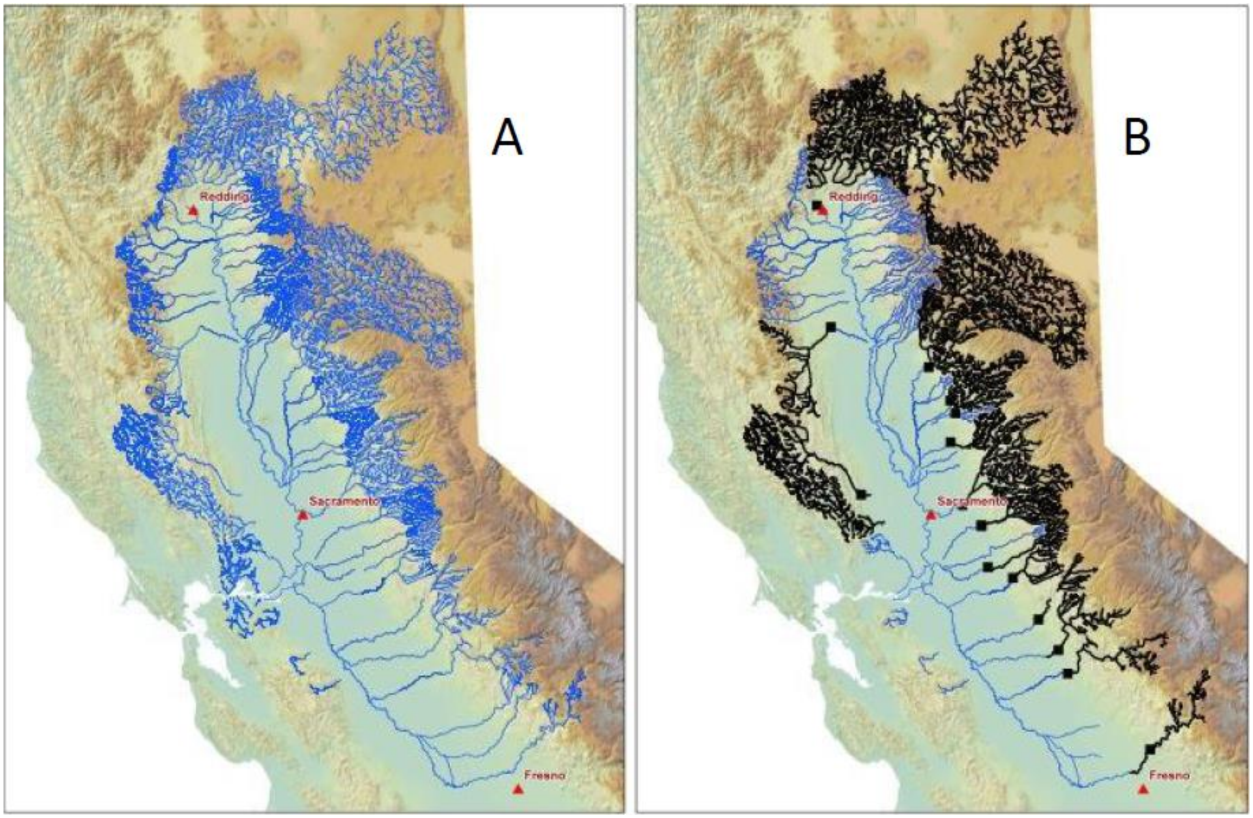


Figure 32: Historical habitat accessible to salmonids (A, in blue) and lost upstream habitat (B, in black) from construction of impassible dams (black squares). Remaining anadromous salmon habitat is confined to the valley floor (B, in blue).

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).

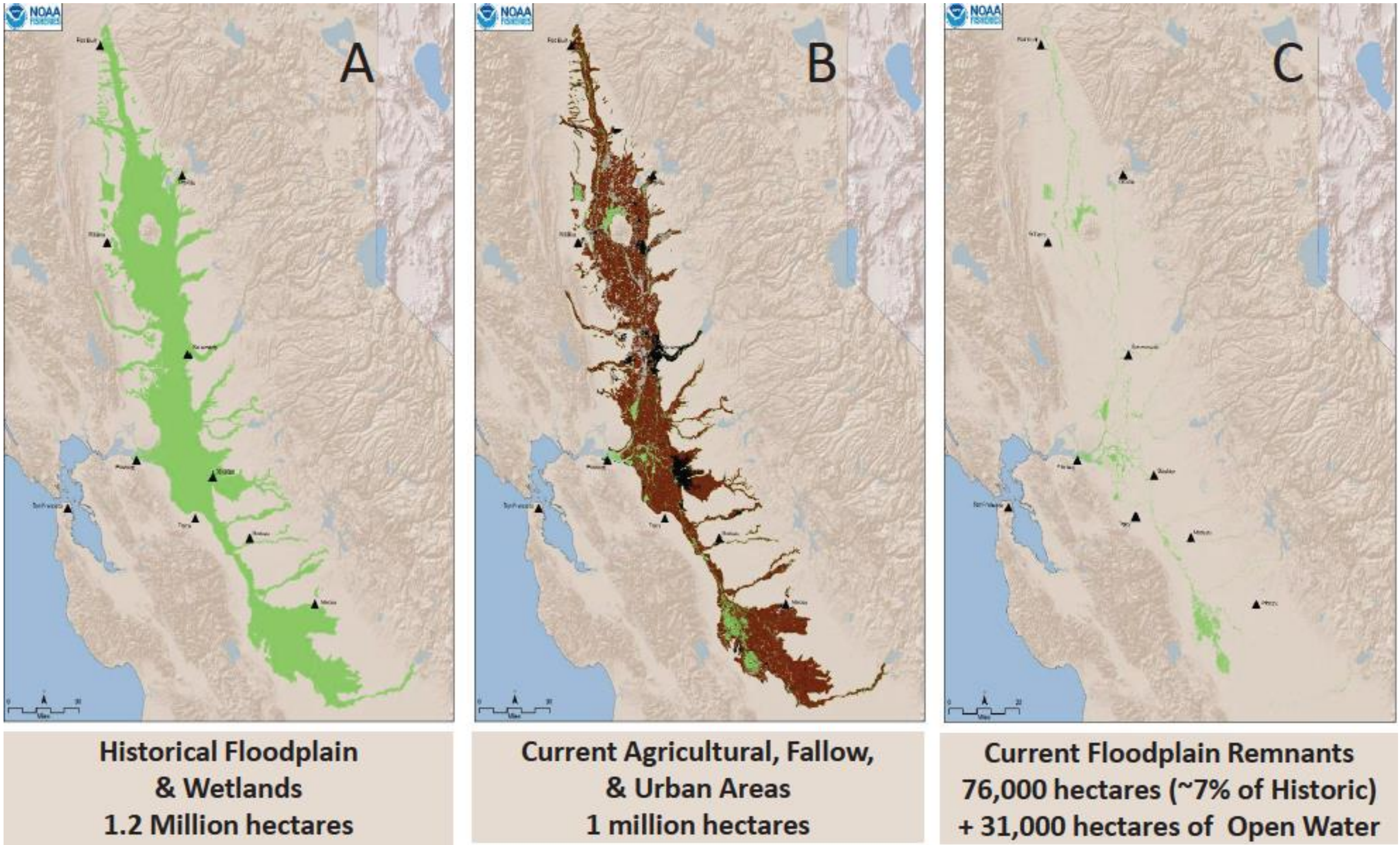


Figure 33. Historical floodplain and Delta wetlands habitat; (B) remnant floodplain and wetland habitat currently in agricultural lands, fallow lands, or urban areas; and (C) floodplain and wetland remnants.

Source: (Herbold et al. 2018)

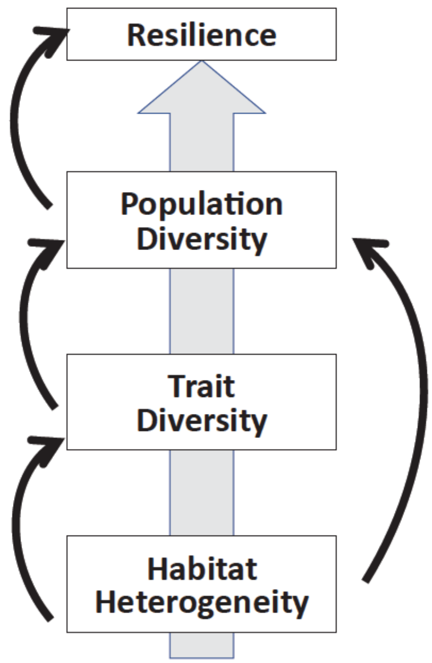


Figure 34. Conceptual model of how habitat heterogeneity creates trait and phenotypic diversity to promote population resilience.

Source (Herbold et al. 2018)

7.3 Water Management

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).

To help put the Central Valley outflow reductions in context it is helpful to look at how other aquatic ecosystems have responded to water extractions. Richter et al. (2012) concluded that flow modifications greater than 20 percent likely result in moderate to major changes in natural structure and ecosystem function, with greater risk associated with greater levels of alteration. Based on published studies of European and Asian rivers, Rozengurt et al. (1987) concluded that when successive spring and annual water withdrawals exceeded 30 percent and more than 40-50 percent of the normal unimpaired flow respectively, water quality and fishery resources in the river and estuary ecosystems deteriorated to levels which overrode the ability of the system to restore itself. In the context of Richter et al. (2012) and Rozengurt et al. (1987), it is not surprising that native fish and wildlife in the Bay-Delta watershed have been significantly impacted by removing over half of the water. Water diversions and the corresponding reduction in flows are not the only factor contributing to Central Valley anadromous fish species declines, but they are a significant one (State Water Resources Control Board 2017a).

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 (Figure 35) combined with the location of the pumps in the south Delta result in significantly modified hydrologic (Figure 36) and biological systems (Cummins et al. 2008). The Public Policy Institute of California summarized the changes and resultant impact on native fish as follows:

> "*After the SWP began operations in the late 1960s, the combined effects of CVP and SWP impoundments and diversions—along with those of hundreds of other water users—became clearly apparent. River flows and water quality declined, threatening both economic and environmental uses; and the ecological balance of the Delta became disastrous to native fish species (Lund et al. 2010; Lund et al. 2007; Moyle and Bennett 2008). The conversion of the 700,000-acre tidal freshwater marsh to a network of rock-lined channels had severely limited available habitat for fish, and dramatic reductions in the quantity and quality of Delta inflows further degraded that habitat. As the SWP increased its exports in the 1980s—almost doubling direct extractions from the Delta—conditions reached a crisis point (Figure 1.4)"* (Figure 37) (Hanak et al. 2011).

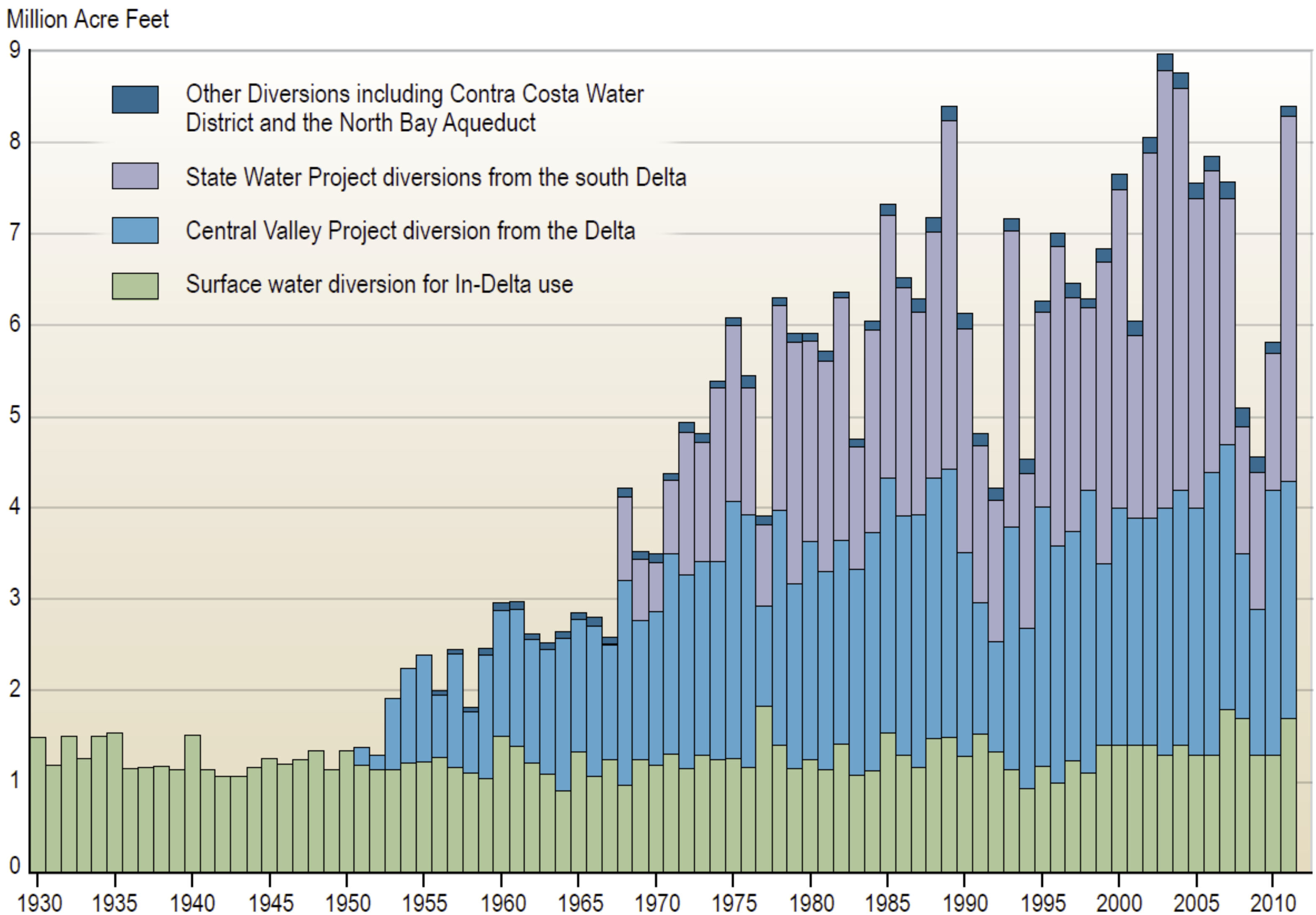


Figure 35. Annual water diversions from within the Delta.

Source: (California Department of Water Resources 2013)

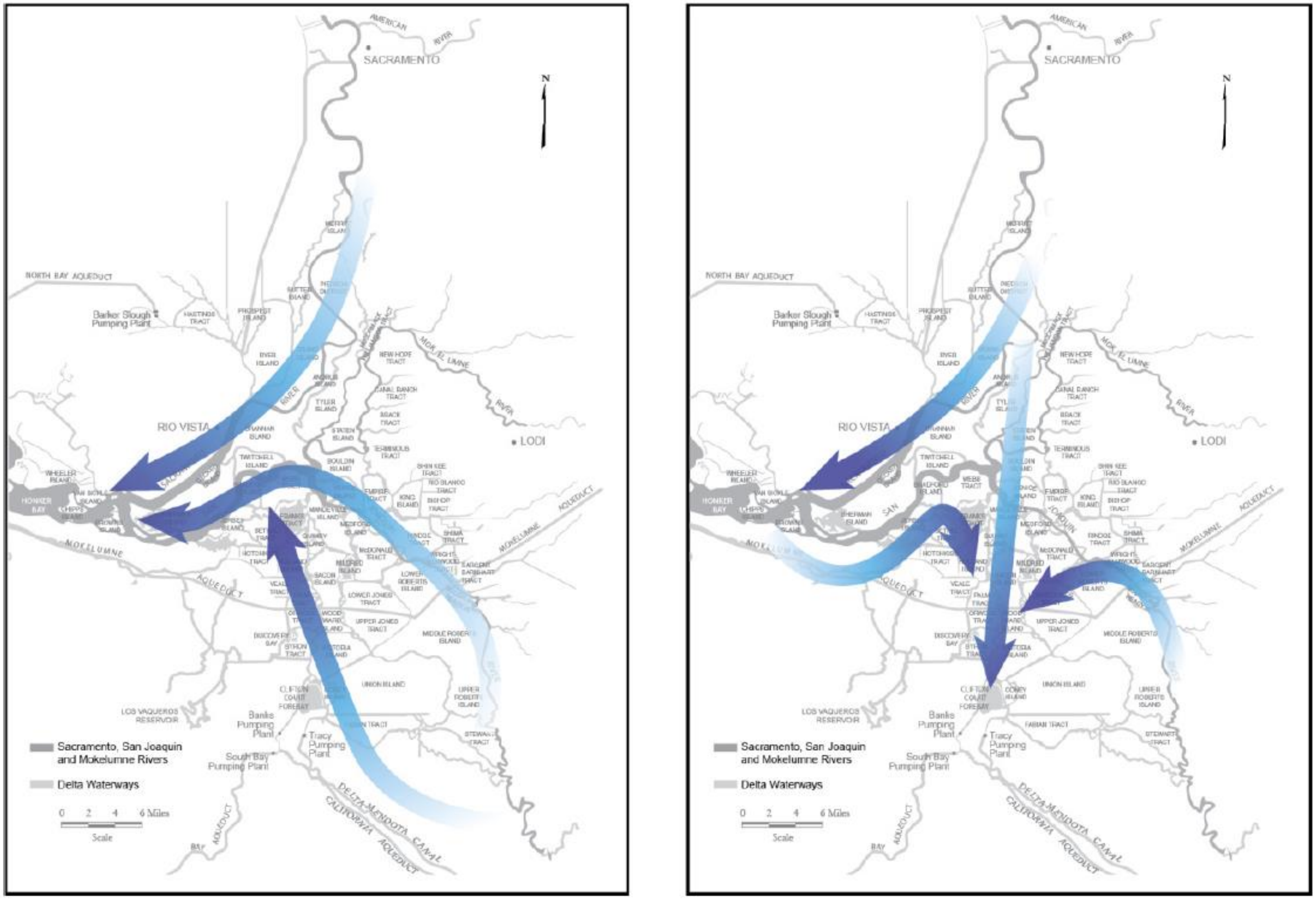
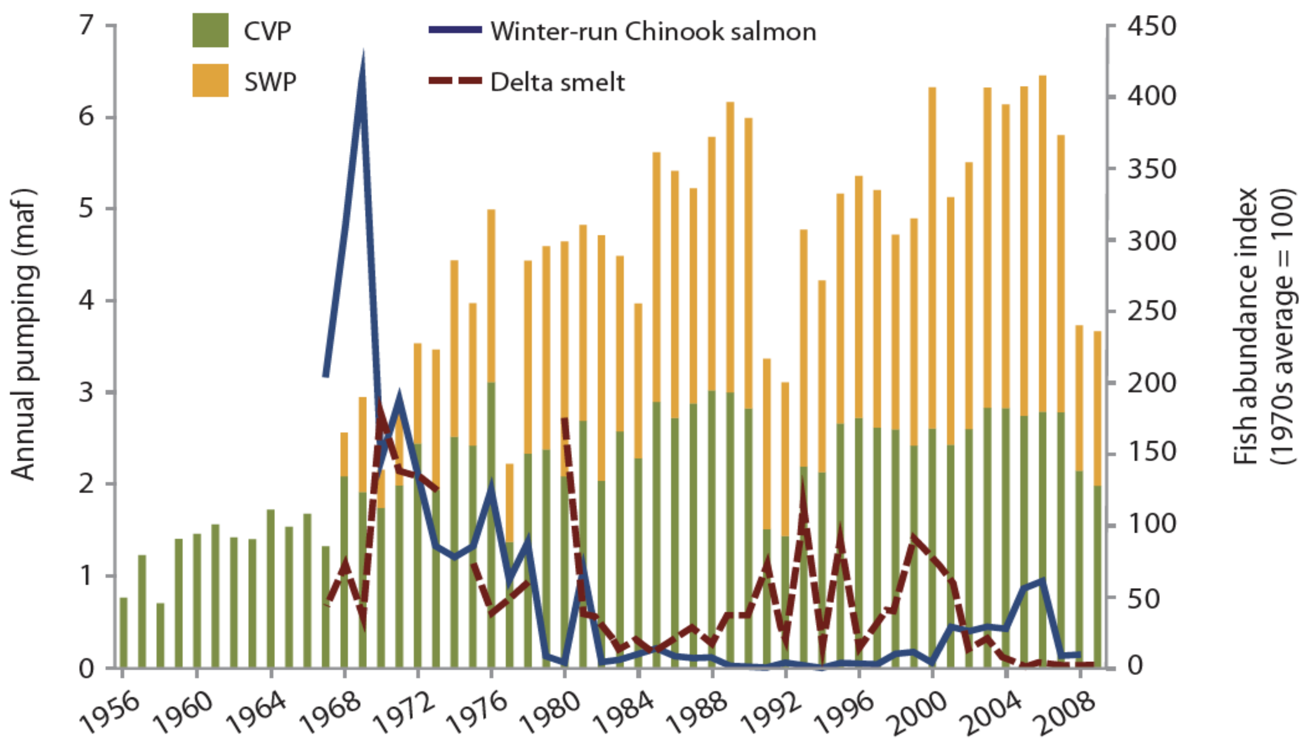


Figure 36. Generalized flow directions in the South Delta. The left panel depicts the tidally averaged flow direction in the absence of export pumping. The right panel depicts reversal of tidally averaged flows that occurs during times of high export pumping.



SOURCES: For Delta exports, California Department of Water Resources Dayflow data; for fish populations, California Department of Fish and Game survey data.

NOTES: Both the CVP and the SWP pump water from the southwestern Delta. CVP exports include pumping from the Contra Costa Water District, which draws from the Contra Costa Canal in the western Delta (roughly 120,000 acre-feet [af] in the 2000s), and SWP exports include pumping from the North Bay Aqueduct, which draws from the northern Delta to supply Solano and Napa Counties (roughly 50,000 af in the 2000s). Series for salmon and adult delta smelt are not available before the years shown.

Figure 37. Native Delta fish populations declined as exports increased.

Source: (Hanak et al. 2011)

Operations of the CVP and SWP prior to the 2009 NMFS Opinion reduced survival of juvenile salmonids outmigrating through the Delta. Prior to the protections established by the NMFS 2009 Opinion (National Marine Fisheries Service 2009b), mortality of winter-run juveniles entering the interior of the Delta (through 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 2009 NMFS 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 2018f). 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. 2014; Poletto et al. 2014). Efforts to salvage green sturgeon at the CVP and SWP have been conducted for decades; the number of green sturgeon observed in these facilities is typically low with a few individuals per year (National Marine Fisheries Service 2018f).

Flow fluctuations from past and current Sacramento River operations management of the CVP have resulted in stranding of juvenile salmonids, Chinook salmon redd dewatering and redd scour in the Sacramento River. High flows have also resulted in CCV steelhead redd scour on the American River but the frequency of redd scouring flows are expected to be slightly lower with completion of the Folsom Dam and Lake Water Control Manuel (National Marine Fisheries Service 2018d).

7.4 Delta Survival

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, a technical team associated with the Collaborative Adaptive Management Team 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, or invasive species, and management actions related to CVP and SWP operations, which are just a few of many interacting drivers (Delta Independent Science Board 2015; Monismith et al. 2014).

Export effects in the south Delta 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. Export effects of ongoing diversions from the south Delta export facilities adversely impact hydrodynamic conditions in the south Delta.

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 negative 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 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 a number of components 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.

- 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.

7.5 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 form and process: 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 green sturgeon (National Marine Fisheries Service 2018f).

7.6 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.

A set of four scenarios was developed by the Intergovernmental Panel on Climate Change (IPCC) to ensure that starting conditions, historical data, and projections are employed consistently across the various branches of climate science. The scenarios are referred to as RCPs, which capture a range of potential greenhouse gas emissions pathways and associated atmospheric concentration levels through 2100 (IPCC 2014). The RCP scenarios drive climate model projections for temperature, precipitation, sea level, and other variables: RCP2.6 is a stringent mitigation scenario; RCP2.5 and RCP6.0 are intermediate scenarios; and RCP8.5 is a scenario with no mitigation or reduction in the use of fossil fuels. The IPCC future global climate predictions (2014 and 2018) and national and regional climate predictions included in the Fourth National Climate Assessment for U.S. states and territories (2018) use the RCP scenarios.

The increase of global mean surface temperature change by 2100 is projected to be 0.3 to 1.7°C (0.5 to 3.1°F) under RCP2.6, 1.1 to 2.6°C (2.0 to 4.7°F) under RCP4.5, 1.4 to 3.1°C (2.5 to 5.6°F) under RCP6.0, and 2.6 to 4.8°C (4.7 to 8.6°F) under RCP8.5 with the Arctic region warming more rapidly than the global mean under all scenarios (IPCC 2014). The Paris Agreement aims to limit the future rise in global average temperature to 2°C (3.6°F), but the observed acceleration in carbon emissions over the last 15 to 20 years, even with a lower trend in 2016, has been consistent with higher future scenarios such as RCP8.5 (Hayhoe et al. 2018).

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 (Hayhoe et al. 2018). The *IPCC Special Report on the Impacts of Global Warming* (IPCC 2018) noted that human-induced warming reached temperatures between 0.8 and 1.2°C (1.4 and 2.2°F) above pre-industrial levels in 2017, likely increasing between 0.1 and 0.3°C (0.2 and 0.4°F) per decade. Annual average temperatures have increased by 1.8°C (3.2°F) across the contiguous U.S. 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 heatwaves in most land regions and an increase in the frequency and duration of marine heatwaves (IPCC 2018). 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 2018).

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 (Department of Water Resources 2018).

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 (Dettinger et al. 2004; Roos 1991). Specifically, the Sacramento River basin annual runoff amount for April-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 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 climate warms by 5°C (9°F), it is questionable whether any Central Valley Chinook salmon, and green sturgeon populations can persist (National Marine Fisheries Service 2018f; Williams 2006).

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 green sturgeon juvenile rearing habitat and adult migration corridors (CH2M HILL 2014; National Marine Fisheries Service 2018f).

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 (CH2M HILL 2014; Knowles and Cayan 2002). 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.

Recent studies have provided evidence that 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 (aka "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. 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).

7.7 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 outmigration 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. 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 foodweb 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 and largemouth bass. 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 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 present and coexisting with green sturgeon in the Sacramento 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 1997b). 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 winter-run Chinook salmon. Extensive areas of the Delta are below mean high tide, but because of levees and flapgates 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 foodweb organisms (CALFED Bay-Delta Program 2000).

The multi-agency SAIL synthesis teams (Windell et al. 2017) found predation by non-native species affected egg survival, timing, and condition and juvenile survival, residence time/migration, and growth.

7.8 Loss of Riparian Habitat and Instream Cover

During the development of the Recovery Plan for Central Valley Chinook Salmon and Steelhead (National Marine Fisheries Service 2014b), loss of riparian habitat and instream cover was identified as a primary stressor affecting the recovery of the species. This threat primarily affects the juvenile rearing and outmigration 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 be a healthy riparian habitat and many terrestrial invertebrates also depend on this habitat. Studies by the California Department of Fish and Game demonstrated that a significant portion of juvenile Chinook salmon diet is composed of terrestrial insects, particularly aphids which are dependent on riparian habitat (National Marine Fisheries Service 1997b).

The multi-agency SAIL synthesis teams also identified the relevant pathways by which loss of riparian habitat and instream cover is likely to affect species 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.

7.9 Loss of Natural River Morphology and Function

During the development of the Recovery Plan for Central Valley Chinook Salmon and Steelhead (National Marine Fisheries Service 2014b), loss of natural river morphology and function was identified as a primary stressor affecting the recovery of the species. This threat primarily affects the juvenile rearing and outmigration 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 affect species as well as how it is likely to interact with other stressors. Specifically, Windell et al. (2017) focused the impact of channelized, leveed, and riprapped reaches potentially having low habitat complexity, low abundance of food organisms, and offer little protection from predators – factors which juveniles are dependent 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 green sturgeon adults within the Sacramento River Basin and a medium threat to other life stages in the Sacramento River Basin. 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. green sturgeon requires deep pools for spawning and holding in the Sacramento River Basin. Large impoundments (e.g., Oroville, 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 (2016b) indicates 50 to 125 areas with greater than five 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.

7.10 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 2018f). This threat primarily affects the juvenile rearing and outmigration 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 floodplain are key juvenile rearing habitats supporting significantly higher drift invertebrate consumption and therefore faster growth rates (Katz et al. 2017; Sommer et al. 2001a). 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 affect species 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).

7.11 Spawning Habitat Availability

During the development of the Recovery Plan for Central Valley Chinook Salmon and Steelhead (National Marine Fisheries Service 2014b), Spawning Habitat Availability was identified 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 1997b). Upper preferred water temperatures for spawning Chinook salmon range from about 55°F to 57°F (Reiser and Bjornn 1979). The NMFS 2009 Opinion requires water temperatures to be maintained below 56°F in the upper Sacramento River above the Red Bluff Diversion Dam (National Marine Fisheries Service 2009b). 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 1997b). 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: 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 2009b) 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 is restricted to the mainstem and a few river tributaries in the 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).

7.12 Physical Habitat Alteration

During the development of the Recovery Plan for Central Valley Chinook Salmon and Steelhead (National Marine Fisheries Service 2014b), physical habitat alteration was identified 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 1997b). 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 1997b). 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.

7.13 Predation

During the development of the Recovery Plan for Central Valley Chinook Salmon and Steelhead (National Marine Fisheries Service 2014b), predation was identified as a primary stressor affecting the recovery of the species. This threat primarily affects the juvenile rearing and outmigration 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 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 nonnative 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 winter-run Chinook salmon, especially in the Delta where there are high densities of non-native fish (e.g., small and large mouth bass, striped bass, catfish, and sculpin) that prey on outmigrating 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 upper Sacramento River, rising of the gates at the Red Bluff Diversion Dam reduces potential predation at the dam by pikeminnow. In the ocean, and even the Delta environment, salmon are common prey for harbor seals 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, white catfish, largemouth bass and bluegill. 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) anectodal 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 affect species 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 outmigrating 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; Michel et al. 2015; Vogel 2011). 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.

Predation in the ocean contributes to natural mortality of salmon in addition to predation in freshwater and estuarine habitats, and salmonids are 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. 2017). 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. 2017). 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. 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. 2017).

7.14 Hatchery Effects

During the development of the Recovery Plan for Central Valley Chinook Salmon and Steelhead (National Marine Fisheries Service 2014b), Hatchery effects was identified as a primary stressor affecting the recovery of the species. This threat primarily affects the juvenile rearing and outmigration 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, two million spring-run Chinook salmon, one million late fall-run Chinook salmon, 0.25 million winter-run Chinook salmon, and two million steelhead are released annually from six hatcheries producing anadromous salmonids in the Central Valley. All of these facilities are currently operated to 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 mitigated for 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 outmigration, 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.

Recent biological opinion on the hatchery and genetic management plan for the Livingston Stone National Fish Hatchery (National Marine Fisheries Service 2017b) 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 depressed 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 is likely to affect species as well as how it is 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 FWS. California's anadromous fish hatcheries produce ESA-listed Chinook salmon (Sacramento River winter-run Chinook salmon and CV spring-run Chinook salmon) and CCV steelhead. Production of non-listed Central Valley 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, Livingston Stone National Fish Hatchery, Coleman National Fish Hatchery, Feather River Fish Hatchery, Nimbus Fish Hatchery, and Mokelumne Fish Hatchery currently produce Chinook salmon and all of them except for Livingston Stone National Fish Hatchery 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 over-exploitation 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 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 predominate 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 Feather River Fish Hatchery have posed a significant threat to the genetic integrity of natural spawning fall- and 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 Feather River Fish Hatchery, 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 spring- and fall-run Chinook salmon adults. This concurrent spawning has led to hybridization between the spring- 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; National Marine Fisheries Service 2016d).

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 Feather River Fish Hatchery. 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, Livingston Stone National Fish Hatchery propagates 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 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 Livingston Stone National Fish Hatchery 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 Livingston Stone National Fish Hatchery can contribute to the recovery of listed species. It is important to note that relative abundance is only one component of a viable salmonid population and managers must also consider the possible adverse impacts of hatchery influence in the long-run, such as reduced fitness of the population.

As described in Appendix G the FWS has been engaged in efforts regarding Coleman National Fish Hatchery and Livingston Stone National Fish Hatchery and their contribution to the management and restoration of Chinook salmon in the Sacramento River and Battle Creek. These efforts are: (1) improving Livingston Stone National Fish Hatchery; (2) implementing the Battle Creek Reintroduction Plan; (3) designing and 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 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 Livingston Stone National Fish Hatchery include:

1. During the drought in 2014 and 2015, and at the request of NMFS and CDFW, Livingston Stone National Fish Hatchery increased production of 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 a just few occasions. Subsequently Reclamation has funded a small permanent chiller to ensure temperatures for egg incubation only.
2. Several years ago, Reclamation funded, and the FWS operated the Anderson-Cottonwood Irrigation District trap, a fish trap on the north side of the Sacramento River at Caldwell Park. To date, only two salmon have been collected at that site and the FWS ceased operating the trap this year.
3. The FWS partners with the CDFW for much of the monitoring for winter-run Chinook salmon on the Sacramento River. FWS efforts include coded-wire tagging and marking Livingston Stone National Fish Hatchery-produced 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 FWS efforts, mostly out of the operational funding agreement for Coleman National Fish Hatchery and Livingston Stone National Fish Hatchery and the Opinion monitoring agreement with the FWS' Red Bluff Fish and Wildlife Office. Both of these are long-term agreements with a history of renewal.

Specific ongoing actions for improving the implementing the Battle Creek Reintroduction Plan include:

1. In 2017, Livingston Stone National Fish Hatchery had excess winter-run Chinook salmon broodstock on station. This occurred because extra captive broodstock were being kept in the event 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 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 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 winter-run Chinook salmon juveniles into its annual operations and approximately 200,000 winter-run were release in the North Fork of Battle creek again in 2019. This currently involves spawning broodstock and rearing eggs at Livingston Stone National Fish Hatchery, then transferring fry to Coleman National Fish Hatchery for further rearing and release. A release of this size (~184,000 juveniles) was done in spring 2019, and these releases are expected to continue into the future.

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

1. The FWS 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 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 FWS 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. Evaluation of 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. To date, the FWS has implemented one year of a three-year study, largely through the use of Coleman National Fish Hatchery operational funds, acoustic tags provided by Reclamation, tag surgeries provided by University of California Davis, and net pen operations provided by stakeholders and the CDFW’s Mokelumne River Hatchery. The current plan is to run the study for another two years.

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 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 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; ~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 (~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.

7.15 Harvest

The following discussions of harvest impacts for winter-run and spring-run Chinook salmon, and steelhead were, in large part, taken from the most recent NMFS five-year status review reports for each species (National Marine Fisheries Service 2016a; National Marine Fisheries Service 2016b; National Marine Fisheries Service 2016c).

7.15.1 Ocean and Freshwater Harvest of Winter-run Chinook Salmon

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. 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. Fisheries in 2008 and 2009 were closed south of Point Arena owing to the collapse of the Sacramento River fall-run

Chinook salmon stock and insufficient data (i.e., insufficient coded-wire tag recoveries) exist for estimating a 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).

There have been several layers of ocean salmon fishery regulations implemented to protect winter-run Chinook salmon beginning in the early 1990s. For example, a substantial portion of the 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 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) hind casted 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 winter-run Chinook salmon. The most recent and currently applicable 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 Sacramento River 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 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 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 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 winter-run Chinook salmon are actively spawning (and therefore concentrated and more susceptible to impacts). By law, any winter-run Chinook salmon inadvertently hooked in this section of river must be released without removing it from the water. However, 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 winter-run Chinook salmon may be taken.

7.15.2 Ocean Harvest of Spring-run Chinook Salmon

The available information indicates that the fishery impacts on the CV spring-run Chinook salmon ESU have not changed appreciably since the 2010 status review (National Marine Fisheries Service 2016a). 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 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. CV 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 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 Central Valley 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 Sacramento winter-run Chinook 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 Sacramento River 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. Overall, it is highly unlikely that harvest resulted in overutilization of this ESU (National Marine Fisheries Service 2016a).

7.15.3 Salmon Harvest Actions

NMFS has consulted on the effects of numerous salmon fishery harvest actions that may affect Chinook salmon availability in coastal waters for SRKW, including the Pacific Coast Salmon Plan fisheries (National Marine Fisheries Service 2009a), the 10-year term of the Pacific Salmon Treaty (term of biological opinion from 2009-2018; National Marine Fisheries Service (2008a), and 2019-2028; National Marine Fisheries Service (2019b)), and the United States v. Oregon 2018 Management Agreement (term of biological opinion from 2018-2027; National Marine Fisheries Service (2018e)). In these past harvest Opinions, NMFS has considered the short-term effects to SRKW resulting from reductions in Chinook salmon abundance that occur during a specified time period and the long-term 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. These past analyses suggested that short-term prey reductions were small relative to remaining prey available to the whales. In the long term, harvest actions have been designed or modified via 2009 Pacific Coast Salmon Plan Opinion RPM terms and conditions to meet the conservation objectives of harvested stocks in a manner determined not likely to appreciably reduce the survival and recovery of listed Chinook salmon, and therefore ultimately not likely to jeopardize the continued existence of listed Chinook salmon. The harvest Opinions referenced above that considered potential effects to SRKW have all concluded that the harvest actions cause prey reductions, but were not likely to jeopardize the continued existence of ESA-listed Chinook salmon or SRKW.

Ocean harvest rates of Chinook salmon throughout the range of SRKW are highly variable on a stock-by-stock basis as influenced by factors that include variable management goals or limits for different stocks and/or geographic areas, along with variable overlap in fishing effort and the abundance and distribution of stocks and fishing effort. Overall, Hilborn et al. (2012) generally assumed that all salmon fisheries reduced Chinook salmon abundance for SRKW by approximately 20 percent each year under current harvest management regimes. Although precise estimates of exploitation rates for all Central Valley Chinook salmon populations are not readily available, the estimated harvest of Sacramento River fall-run Chinook salmon typically is equal to or exceeds the estimated escapement of fall-run Chinook salmon in the Sacramento River as represented SI used for fisheries management each year (Pacific Fishery Management Council 2019).

As part of the recent the Pacific Salmon Treaty negotiation, the U.S. agreed to develop a targeted funding initiative to mitigate the effects of harvest and other limiting factors by investing in habitat and hatchery actions to increase prey available for SRKW (National Marine Fisheries Service 2019e). Those actions are anticipated to increase Chinook salmon abundance and prey for SRKW by four to five percent throughout their range in Puget Sound waters during the summer, and in coastal areas during the winter when prey is believed to be most limiting. It is expected that an additional 20 million Chinook salmon smolts will be produced by facilities in Puget Sound and along the Washington coast and Columbia River. To a large degree, Chinook salmon from these origins will only overlap with the small percentage of Chinook salmon from the Central Valley that range up to the Columbia River area and northward.

7.15.4 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. 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 2016c). Mean retention from 2007-2008 through 2009-2010 was 13.1 percent, while mean retention from 2010-2011 through 2015-2016 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.

7.15.5 Harvest of Green Sturgeon

Starting in 2006, 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 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 2018f).

7.16 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 Polychlorinated biphenyls (PCBs), organochlorine pesticides, polycyclic aromatic hydrocarbons (PAHs), selenium, and mercury, among others (Brooks et al. 2012; Leatherbarrow et al. 2005; Stewart et al. 2004), 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 (National Marine Fisheries Service 2014b). 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.).

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.

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 are expected to occur in 2021-2023, which will result in reductions in dissolved ammonium concentrations in the Delta. It is scheduled to significantly reduce its nitrogen effluent concentrations beginning in 2023. Once that happens, it should become apparent within a few years how important ammonium ratios are in limiting diatom production in the Bay-Delta. Central Valley Regional Water Quality Control Board (CVRWQCB) 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 (U.S. Environmental Protection Agency 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 have concentrated in aquatic life, but long-term effects and the effects of intermittent exposure are not known (National Marine Fisheries Service 2018d). 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 (U.S. Environmental Protection Agency 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 green sturgeon salmonids utilize in the Delta (National Marine Fisheries Service 2018f).

In December of 2018, the State Water Board 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 (State Water Resources Control Board 2018). The Environmental Protection Agency (EPA) developed an action plan in 2012 to address water quality concerns in the Delta (U.S. Environmental Protection Agency 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 contaminates within the Delta is limited and not likely to affect reproduction. However, survival and growth of juvenile salmonids will potentially be affected. In contrast, 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 green sturgeon.

7.17 Water Temperature Management

The environmental baseline considers observed temperature related mortality from the past to the present, including temperature dependent mortality and other mortality factors in the Upper Sacramento River. Reclamation’s construction and operation of the temperature control device in Shasta Reservoir highlight the importance of operations and facilities to address temperature related mortality. Most recent past exposures include the effects of drought, operations and temperatures on very high mortality of natural winter-run Chinook salmon production in 2014 and 2015.

Sacramento River – NMFS’ 2009 Opinion required, through Reasonable and Prudent Alternative (RPA) actions, seasonal operations and summer water temperature management to provide cold water habitat for early life stages of winter-run and CV spring-run Chinook salmon each year (National Marine Fisheries Service 2009b).

On August 2, 2016, Reclamation requested using the adaptive management provision in the NMFS 2009 Opinion related to Shasta Reservoir operations. The basis for this request included recent, multiple years of drought conditions, new science and modeling, and data demonstrating the low population levels of endangered winter-run Chinook salmon and threatened CV spring-run Chinook salmon. In response, Reclamation implemented a 2017 pilot approach that applied new science on the thermal tolerance of Chinook salmon eggs (Martin et al. 2016) and which was designed to efficiently utilize Shasta Reservoir's limited supply of cold water by basing the spatial distribution of protective temperatures on the within-season spatial distribution of winter-run Chinook salmon redds. The intent was to provide daily average water temperatures of 53°F or less to the Clear Creek gauging station as a surrogate for the furthest downstream redds. The 2009 RPA requirement was a daily average temperature of 56°F or less at compliance locations between Balls Ferry and Bend Bridge, which are not based on the within-season redd distribution. Under the 2017 pilot approach, along with one of the wettest years on record (in water year 2017), resulted in an estimated 44 percent egg-to-fry survival, one of the highest estimates on record. The pilot approach was implemented in 2018 and is also being implemented in 2019. In July 2019, CDFW aerial redd surveys indicated redd distribution was further downstream than the targeted temperature management location at CCR. Per the request of the fish agencies, and as a result of Reclamation's temperature modeling that indicated the operation was feasible, on August 7, 2019, Reclamation initiated temperature management to target 53.5°F at the Airport Road location. The effects of Sacramento River water-temperature management for listed spring-run and winter-run Chinook salmon eggs on the growth rate of juvenile green sturgeon have been modeled, and there was relatively little impact on the growth rate of the species (Hamda et al. 2019).

Clear Creek – 2009 RPA Action I.1.4 Spring Creek Temperature Control Curtain - required Reclamation to replace the Spring Creek Temperature Control Curtain in Whiskeytown Lake by 2011, with the objective to reduce adverse impacts of project operations on water temperature for listed salmonids in the Sacramento River. The curtain was replaced in 2011. In addition, the Oak Bottom Temperature Control Curtain, which is located at the upper end of Whiskeytown Reservoir and intended to enhance coldwater transport from the upper end of the reservoir to the lower reservoir outlets, including Spring Creek Tunnel and Whiskeytown Dam, was replaced in May of 2016. Having both temperature curtains functioning together in tandem enhance cold-water availability in the Spring Creek Tunnel and Whiskeytown Dam outlets, and Reclamation's Technical Service Center is currently evaluating their performance, with a final report expected in 2019.

RPA Action I.1.5 Thermal Stress Reduction **-** required Reclamation to reduce thermal stress to over-summering CCV steelhead and CV spring-run Chinook salmon during holding, spawning, and egg incubation by managing Whiskeytown releases to meet a daily water temperature of (1) 60°F at the Igo gauge from June 1 through September 15, and (2) 56°F at the Igo gauge from September 15 to October 31. Reclamation has operated releases for temperature management since implementation of the 2009 RPA action, though criteria was not met in some years.

The 2009 RPA action also required Reclamation, in coordination with NMFS, to assess improvements to modeling water temperatures in Clear Creek and identify a schedule for making improvements. In the NMFS, 2011 amendment to the NMFS 2009 Opinion, the need to *"*explore options to avoid non-compliance with the RPA*"* was specified for this action. To date, an assessment of and schedule for making improvements to modeling water temperatures in Clear

Creek has not been completed. Beginning in late 2016, Reclamation initiated a temperature model development process, focused on developing a model for Shasta and Keswick reservoirs, with future plans to expand the model to the Trinity Division.

American River - 2009 RPA Action II.3 required Reclamation to implement physical and structural modifications to the American River Division of the CVP in order to improve water temperature management. The purpose of these physical and structural modifications are to facilitate more control over temperature and amount of water releases into the American River for spawning Chinook salmon and steelhead, and migrating and rearing juveniles of both species. Implementation has been delayed, but Reclamation has indicated that some work is being done on the temperature control device at Folsom Dam. In addition, annual water temperature management plans for the lower American River have been developed annually starting in 2010. An Iterative Coldwater Pool Management Model was developed by Reclamation in 2010 and is being used annually to evaluate coldwater pool availability in Folsom Reservoir and develop water temperature objectives in the lower American River that are as protective as possible for salmonids. Despite these efforts, current water temperatures in the lower American are annually stressful for juvenile steelhead rearing over the summer and fall-run Chinook salmon adults returning to spawn.

7.18 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 have been 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 green sturgeon has not been developed (but seeVerhille et al. 2014), and the benefits of projects intended to reduce salmonid impingement and entrainment at diversions to green sturgeon are not fully understood (National Marine Fisheries Service 2018f).

A NMFS 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 2009c). 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 winter-run Chinook salmon, spring-run Chinook salmon, and 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 (rkm 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 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 2018f). This action has had a major beneficial impact on spawning distribution for green sturgeon and possibly aided in population recovery (National Marine Fisheries Service 2018f).

7.19 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. 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).

7.20 Restoration Actions from 2009 Reasonable and Prudent Alternative

Required restoration actions from the RPA in the NMFS 2009 Opinion (National Marine Fisheries Service 2009b) and the associated 2011 amendments (National Marine Fisheries Service 2011d), are described below, and the status of their implementation. Additional updated information related to restoration actions are available in the Salmon Resiliency Strategy (California National Resources Agency 2017).

RPA Action I.7: Reduce Migratory Delays and Loss of Salmon, Steelhead, and Sturgeon at Fremont Weir and Other Structures in the Yolo Bypass (Improve Yolo Bypass Adult Fish Passage)

Pursuant to the RPA in the NMFS 2009 Opinion (National Marine Fisheries Service 2009b), Reclamation and DWR shall 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 Wier Adult Fish Passage Project.

These actions in the Yolo Bypass are expected to reduce migratory delays and straying of adult salmonids and sturgeon because insufficient adult fish passage at flood bypass weirs combined with attraction flows leads to stranding risk and reduced fish survival, timing, and condition. This action is expected to result in improvements to the migration corridor, and help 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 2018f).

RPA Action I.6.1: Restoration of Floodplain Rearing Habitat (Increase Juvenile Salmonid Access to Yolo Bypass, and Increase Duration and Frequency of Yolo Bypass Floodplain Inundation)

Pursuant to the RPA in the NMFS 2009 Opinion (National Marine Fisheries Service 2009b), Reclamation, and DWR shall 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 shall be operated to increase the duration and frequency of Yolo bypass inundation from December through April, providing 17,000+ acres of enhanced floodplain habitat. This is expected to benefit salmonids because lack of floodplain connectivity limits food availability and production and leads to reduced fish growth and subsequent survival. Reclamation received a final biological opinion on the Project from NMFS on May 10, 2019 and the Final Environmental Impact Statement/Environmental Impact Report (EIS/EIR) was released June 7, 2019. Reclamation expects to construct the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project in 2020 or 2021. This action 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 green sturgeon juveniles (National Marine Fisheries Service 2018f).

RPA Action Suite V, NF 4: Implementation of Pilot Reintroduction Program (Implementation of Pilot Reintroduction Program above Shasta Dam)

Pursuant to the RPA in NMFS 2009 Opinion (National Marine Fisheries Service 2009b), Reclamation, and DWR shall complete all required actions, monitoring, and reporting to guide establishment of an additional population of winter-run Chinook salmon and identify the benefits and risks of reintroduction for CV spring-run Chinook salmon and CCV steelhead in the McCloud River and/or upper Sacramento River. Reintroduction is also a Priority 1 NMFS recovery action. Additional updated information related to implementation is available in the Salmon Resiliency Strategy (California National Resources Agency 2017).

In 2010, pursuant to the requirements of RPA Action V in the NMFS 2009 Opinion (National Marine Fisheries Service 2009b), Reclamation established the Interagency Fish Passage Steering Committee, with representatives from Reclamation, NMFS, FWS, United States Forest Service (USFS), CDFW, DWR, State Water Resource Control Board, and University of California Davis. The Steering Committee focused preliminary evaluation efforts on fish passage above Shasta Dam, Folsom Dam and the upper Stanislaus River. By 2013, focus on the fish passage program was limited to the upper Sacramento and McCloud rivers due in large part to the scope of the RPA and concerns over the endangered status of SR winter-run Chinook salmon.

A habitat assessment was completed in 2014 on stream reaches between Shasta Reservoir and McCloud Dam on the McCloud River and up to Box Canyon Dam on the upper Sacramento River (RPA Action NF2). The assessment identified the quality of the habitat and areas suitable for winter-run Chinook reproduction. Additional follow-up habitat assessment work occurred in 2017-2018 on the upper McCloud River and upper Pit River areas. A final fish passage pilot plan for the Shasta Reservoir system was completed (RPA Action NF 3) that outlines how studies should proceed to collect information on the feasibility for a long-term reintroduction upstream of Shasta. Two initial test fish releases, using surrogates (late fall Chinook), occurred in 2017 to evaluate whether juvenile Chinook would successfully transit between the McCloud River and Shasta Dam, potentially enabling juvenile collection to occur at the dam rather than near the head of the reservoir. Chinook transited the reservoir at around a 70 percent success rate under high flow conditions and at around one percent success under normal water flow. This supports the expectations described in the RPA that the project may be most successful with juvenile collection near the head of the reservoir. Reclamation funded NMFS to include an upstream of Shasta component in the winter-run life cycle model. This modeling showed that under some conditions, the reintroduced population would be close to self-sustaining. Reclamation conducted a prize competition to develop potential solutions to juvenile downstream passage around high dams. More than 40 solutions were received from across the country with some ideas with potential for incorporation in a final passage project.

Reclamation prepared a draft environmental assessment for pilot plan implementation in 2015, updated the document in 2017, and then moved to an Environmental Impact Statement in 2017 to address resource conflicts. To date, the EIS has not been released. In 2018, Reclamation awarded DWR 2.7 million dollars as the first installment of a five-year contract totaling approximately 9 million dollars for the design, construction, installation, and operation of two juvenile fish collection devices in the lower McCloud River and the McCloud arm of Shasta Reservoir (RPA Action NF 4.5 – juvenile fish collection prototype). Information on the Shasta Dam Fish Passage Evaluation can be found at Reclamation's Shasta Dam fish passage evaluation web page.

RPA Action IV.1.3: Consider Engineering Solutions to Further Reduce Diversion of Emigrating Juvenile Salmonids to the Interior and Southern Delta, and Reduce Exposure to CVP and SWP Export Facilities (Including Georgiana Slough Non-Physical Barrier)

Pursuant to the RPA in the NMFS 2009 Opinion (National Marine Fisheries Service 2009b), DWR, Reclamation and the State and Federal Water Contractors shall increase the overall through-Delta survival of salmonids by reducing juvenile salmon entry into the interior Delta. This action is expected to benefit salmonids because it affects multiple habitat attributes that are hypothesized to affect juvenile survival, including predation and competition, outmigration cues, and entrainment risk.

Work on this RPA has been organized into three phases consisting of multi-year studies. Phase I (2011 – 2013) included formation of a Technical Working Group consisting of representatives from DWR, CDFW, Reclamation, NMFS, and FWS. 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 would focus 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 includes planning and conducting a five-year fish diversion and salmon protection technology implementation program and evaluation in the Sacramento River using a Bio-Acoustic Fish Fence, Floating Fish Guidance Structure, or Infrasound Fish Fence at locations that will provide the largest resource benefit. Locations under consideration include Georgiana Slough, Steamboat Slough, and Sutter Slough. The most current schedule is for DWR construction of a non-physical barrier(s) to begin in 2020. Construction completion and efficacy testing would begin in early 2021.

This action is consistent with a priority 1 NMFS recovery action for winter-run Chinook salmon.

RPA Action I.2.6: Restore Battle Creek for Winter-Run, Spring-Run, and CV Steelhead (Complete Battle Creek Salmon and Steelhead Restoration Project)

Pursuant to the RPA in the NMFS 2009 Opinion (National Marine Fisheries Service 2009b), Reclamation, and DWR shall direct discretionary funds to implement the Battle Creek Salmon and Steelhead Restoration Project for the benefit of 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 one-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 occured and we expect further benefits to listed salmonids once completed. In August 2016, the CDFW released 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 winter-run Chinook in North Fork Battle Creek, which will contribute to the recovery of the Sacramento River winter-run Chinook Salmon. This Reintroduction Plan describes the process for reintroducing winter-run Chinook 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 FWS subsequently agreed to take on responsibility for implementing the plan.

In 2017, Livingston Stone National Fish Hatchery had excess winter-run Chinook broodstock on station. This occurred because extra captive broodstock were being kept in the event additional fish were needed to supplement the mainstem Sacramento River program because of drought conditions. The FWS, in coordination with NMFS and CDFW determined that the captive broodstock were not needed for the Sacramento program and agencies decided to use those fish to produce juveniles for release into Battle Creek to "jumpstart" the reintroduction of winter-run Chinook in advance of the implementation of the Reintroduction Plan and the complete restoration of Battle Creek. This method of reintroducing winter run to Battle Creek differs from the recommendations from the Reintroduction Plan, which calls for using the progeny of wild-caught broodstock. The jumpstart effort is intended to transition into implementation of the Reintroduction Plan as funding becomes available.

In the spring of 2018, Coleman National Fish Hatchery released 215,000 juvenile winter-run Chinook into upper Battle Creek. The agencies decided to continue this jumpstart effort and a similar number of juvenile winter-run Chinook salmon were released into the North Fork of Battle Creek in 2019. Coleman National Fish Hatchery has subsequently integrated the production of approximately 200,000 winter-run Chinook juveniles into its annual operations. This currently involves spawning broodstock and rearing eggs at Livingston Stone National Fish Hatchery, then transferring fry to Coleman National Fish Hatchery for further rearing and release. Coleman National Fish Hatchery has spent $100 thousand on water chilling infrastructure to help ensure consistent optimal rearing conditions for winter-run Chinook salmon and to eventually be able to spawn fish and rear eggs on station. To date, personnel costs and funding for all aspects of the jump-start program, including feed, rearing, tagging, transportation of fish, and infrastructure have been accomplished with Coleman National Fish Hatchery's operational funding provided annually by Reclamation. The Battle Creek Reintroduction Plan itself includes estimates of costs for implementing the plan amounting to $3.365 million in one-time construction and acquisition costs and $650 thousand in annual costs. The Reintroduction Plan states that these estimates are conceptual and probably low. Two of the four tasks in the Service's recently signed agreement between the FWS and CDFW contribute to implementing the Battle Creek Reintroduction Plan, and give the FWS access to about $14 million to cover mostly the one-time construction and acquisition costs. This funding should be adequate to fully address those costs. As the Reintroduction Plan proceeds further into implementation, additional funding will likely be needed to cover the annual costs.

Other RPA Actions

Specific smaller scale fish habitat restoration actions mandated as part of the NMFS 2009 Opinion (National Marine Fisheries Service 2009b) 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 continuing to contribute to the recovery of ESA-listed salmonids in the Central Valley.

7.21 EcoRestore

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 by 2020. 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 six completed actions as part of EcoRestore to date (California National Resources Agency 2017), which has resulted in improved migration and rearing habitats for listed anadromous fish in the lower Sacramento River and Delta. Completed actions include:

1. 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.
2. 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 marshplain 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 one-mile tidal channel.

3. 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.
4. 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 project; determining the air and water quality impacts of project; and providing recommendations for Delta-wide implementation. This project was initiated in 2013 and was completed in 2015.
5. 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.
6. 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 storm water 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 the 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 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 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 SRS Contractor's 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.

7.22 Scientific Research

Research activities on SRKW are typically conducted between May and October in inland waters, and some permits include authorization to conduct research in coastal waters as well. In general, the primary objective of this research is population monitoring or data gathering for behavioral and ecological studies. Recent permits issued by NMFS include research to characterize the population size, structure, feeding, ecology, behavior, movement patterns and habitat use of the SRKW, especially during the winter and spring when SRKW are using coastal waters extensively. Impacts from permitted research include temporary disturbance and potential short-term disruptions or changes in behavior such as feeding or social interactions with researchers in close proximity, and any minor injuries that may be associated with biopsy samplings or attachment of tags for tracking movements and behavior. We note that in 2016, a SRKW (L95) was found to have died of a fungal infection that may have been related to a satellite tag deployment approximately 5 weeks prior to its death (Carretta et al. 2018).

7.23 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.

The proposed action includes restoration actions with annual implementation and are described as conservation measures in Table 4-6 of the ROC on LTO biological assessment (U.S. Bureau of Reclamation 2019c). 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 Central Valley Project Improvement Act.

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.

7.24 Conservation/Mitigation Banks

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 a 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 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, FWS, 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: Sacramento River 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. Of the 139.11 acres available for salmonids, approximately 68 acres have been purchased. 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 Sacramento River 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. To date, there have been less than 25 percent of the 100 credits sold and the ecological value (increased rearing habitat for juvenile salmonids) of the sold credits are part of the environmental baseline. Features of this bank are designated critical habitat for Sacramento River 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 Sacramento River 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. To date, there have been approximately ten percent of the 119.65 credits sold and the ecological value (increased rearing habitat for juvenile salmonids) of the sold credits are part of the environmental baseline. Features of this bank are designated critical habitat for the Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon.

7.25 Importance of the Action Area for the Survival and Recovery

The action area defined for this proposed action includes critical habitat designated for all species of ESA-listed fish addressed in this Opinion. It includes 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.

The NMFS Recovery Plan for Central Valley salmonids (National Marine Fisheries Service 2014b) provides region-specific 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 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 is being managed by CVP operations. However, implementation of a "jump start" to the reintroduction plan to Battle Creek began in 2018. Reintroduction to McCloud River was part of the 2009 RPA, but has not been implemented past initial studies to date (further description is provided above in Section 2.4.2.9 Restoration Actions from 2009 NMFS RPA).

Recovery criteria for the 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 upper Yuba River (in the Northern Sierra Nevada Diversity Group); and in the Southern Sierra Nevada Diversity Group - 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 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 2018f) include demographic recovery criteria (abundance, distribution, productivity, and diversity) and threat-based recovery criteria (significant known threats impeding recovery).

8 Effects of the Action on Species

Section 7 regulations define "effects of the action" as the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline (50 CFR 402.02). Indirect effects are those that are caused by the proposed action and are later in time, but are reasonably certain to occur.

Under the ESA, the term "take" means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct. For this consultation, we are particularly concerned about activities that may kill an animal or result in behavioral and physiological disturbances that may result in the failure of an animal to feed or breed successfully, or otherwise impede animals' ability to complete their life history functions (i.e., a decrease in fitness).

Below we describe the primary stressors created by the proposed action by Division (Table 15) and the models used to assess the affects to species. Then we summarize our analysis of the effects of the proposed action. Where possible, we used models to analyze potential effects. Reclamation used models for its biological assessment that was initially provided to NMFS on January 31, 2019 ((U.S. Bureau of Reclamation 2019c), the original proposed action). NMFS also requested additional modeling by Reclamation which was done in early 2019. As the consultation proceeded, and the proposed action was updated, NMFS conducted subsequent qualitative analyses that are included in this effects section. In this way changes to Reclamation's proposed action, which are intended to increase certainty in the proposed action, minimize potential adverse effects or increase potential beneficial effects to listed species and designated critical habitat, were incorporated into these analyses.

Table 15. Species for which the effects are analyzed in each Bureau of Reclamation Central Valley Project Division.

Division / **Species**	***Upper Sacramento/Shasta Division***	***Trinity Division***	***American River Division***	***Bay-Delta Division***	***Stanislaus River***	***San Joaquin River*** [1]
Sacramento River winter-run Chinook salmon	X	-[5]	-[2]	X	-	-
Central Valley spring-run Chinook salmon	X	X	-	X	-[6]	-[6]
California Central Valley steelhead	X	X	X	X	X	X
Southern Distinct Population Segment green sturgeon	X	-	-	X	- [3]	X
Southern Resident Killer Whale [4]	-	-	-	-	-	-

[1] *This area is defined as the reach of the San Joaquin River between the confluence with the Stanislaus River and approximately Mossdale.*
[2] *In addition to the Sacramento River, juvenile winter-run Chinook salmon have also been found to rear in areas including the lower American River, lower Feather River, Battle Creek, Mill Creek, Deer Creek, and the Delta (Phillis et al. 2018). However, the effects of the action on non-natal rearing juveniles are not considered in the effects analysis.*
[3] *Records of green sturgeon in the San Joaquin River and its tributaries are rare and limited to information from angler report cards.* (Anderson et al. 2018) *recently confirmed an adult green sturgeon holding in a deep pool near Knights Ferry in the Stanislaus River in the fall of 2017. Given the low incidence and lack of population information in these reaches, the effects are not considered in the effects analysis.*
[4] *Effects to Southern Resident killer whale prey is not associated with a specific division.*
[5] *Sacramento River winter-run Chinook salmon occasionally stray into Clear Creek in the Trinity Division. The effects on strays are not considered in the effects analysis.*
[6] *Phenotypically spring-running Chinook salmon are known to occur in the Stanislaus and San Joaquin Rivers, however, we currently have insufficient information to determine whether these individuals are part of the CV spring-run Chinook salmon ESU. The effects in this Division for CV spring-run Chinook salmon are therefore not considered in the effects analysis.*

X: Effects for this Division were analyzed for this species

-*:- Effects for this Division were not analyzed for this species*

8.1 Stressors and Species Response

The following stressors were considered in the analysis of effects of the proposed action: passage impediments/barriers, water temperature, water quality, water flow, and entrainment/ impingement. NMFS uses the description of each stressor as the standard against which to measure the severity or magnitude of impact associated with a particular action component. In this way NMFS measures the effects of the action against the stressors created by the proposed action either increases, decreases, or has an unknown or indiscernible effect on those stressors.

8.1.1 Passage Impediments/Barriers

Natural and artificial barriers can delay the upstream passage and increase energetic costs to migration for salmon. Impediments physically block access to upstream holding and spawning habitats, alter downstream habitat (by disrupting water velocity, temperature, and sediment transport) and eliminate the spatial segregation of spawning habitat that historically existed. This can create cascading effects of fragmented habitat, constrained species distributions, isolate genetic pools, increased competition for spawning sites, and favoring generalist over specialist life histories which poses a particular risk to endemic species (Liermann et al. 2012; Poff et al. 2007).

Passage impediments/barriers typically are manmade structures that constrain connectivity and fragment access between essential habitats. Permanent structures, such as dams, limit freshwater migratory ranges for salmonids and green sturgeon. Construction of permanent impediments/barriers that limit access to spawning habitats affect adult immigration and holding. Barriers physically block access to upstream historic holding and spawning habitats and eliminate spatial segregation of spawning habitats, which historically existed above the barrier, may cause spatial competition among adults. Temporary or operable barriers may delay upstream passage and increase energetic costs to migration for adult salmon. Alternately, operation of temporary or operable impediments may create false migration cues and increase straying of adults, which may alter a population’s genetic characteristics. Generally, operation of temporary or operable barriers in a position matching the connectivity of the historical condition has the least effect on salmon, steelhead, and sturgeon. Effects of the action that contribute to passage impediments/barriers are likely to result in a probable change in fitness by reducing salmon, steelhead, and sturgeon adult reproductive success prior to spawning and reducing Chinook and steelhead salmon egg survival through redd superimposition.

Also, temporary or operable barriers can affect connectivity and migration between juvenile rearing habitats. Passage impediments and barriers may affect juvenile rearing and outmigration life stages of Chinook salmon, steelhead, and sturgeon along their migration routes between the ocean and natal areas. When operated, these impediments influence the access to rearing and migratory habitats. Also, temporary or operable impediments/barriers may affect downstream migration by providing false migration routes for juvenile salmon reducing their success in reaching suitable habitats. Impediments change the routing and travel rates of fish passing these sites, which may increase competition among individuals and expose fish to higher predation in distinct migration routes. Effects of the action that contribute to passage impediments/barriers are likely to result in a probable change in fitness by reducing juvenile Chinook salmon growth and survival.

Passage impendements may also result from high (or low) water temperature or low (or high) flow.

8.1.2 Water Temperature

Water temperature can affect the physiology of ectothermic organisms like salmon and sturgeon at all life stages. These effects can impact the organism directly (e.g., altered metabolic demand), as well as indirectly by altering their habitat (e.g., decreased dissolved oxygen or increased water chemistry reaction rates). Water temperatures can be affected by a number of factors, including air temperatures, elevation, depth, flow and velocity, and presence of riparian vegetation.

Egg-to-fry

Higher water temperatures can affect the early development of salmon by decreasing egg yolk absorption periods and reducing the efficiency at which yolk is converted to tissue.

Based on several studies on CV Chinook salmon, temperatures between 43°F and 54°F appear best suited to Chinook salmon egg and larval development ((Myrick and Cech 2004), Table 16). Several studies indicated that daily temperatures over 56°F would lead to sub-lethal and lethal effects to incubating eggs (Boles 1988; Seymour ; U.S. Environmental Protection Agency 2003; U.S. Fish and Wildlife Service 1999). Recent investigations into causes of mortality upstream also revealed that the 56°F daily average temperature may not be adequate to protect the earliest life stages (Swart 2016). The Martin et al. (2016) egg mortality model found strong evidence that significant thermal mortality occurs at temperatures greater than 53.5°F.

Myrick and Cech Jr (2001) examined the effects of water temperature on steelhead (and Chinook salmon) with a specific focus on Central Valley populations and reported that 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, U.S. Environmental Protection Agency (2001) reported that steelhead egg and alevin survival would decline with exposure to constant water temperatures above 53.6°F. Rombough (1988) found less than four percent embryonic mortality of 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 five percent at all temperatures tested, but alevins hatching at 59°F were considerably smaller and appeared less well developed than those incubated at the lower test temperatures.

In a laboratory study examining survival and development of 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 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 steelhead egg mortality increases at and above a range of 54°F to 57°F (Bratovich et al. 2012; Myrick and Cech Jr 2001; U.S. Environmental Protection Agency 2001).

Given that the literature results are from laboratory studies, 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 greater than 5°F 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 thermal tolerance of eggs developing in the river by roughly 3°C 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). This issue likely applies to what is known about the relationship between thermal tolerance and steelhead survival given that, like Chinook salmon, steelhead eggs incubate under the water column in spawning gravels. The limits of thermal tolerance are set by oxygen supply and demand. As steelhead eggs are smaller than Chinook salmon eggs, it may be expected that their oxygen needs are 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 steelhead eggs and Chinook salmon eggs.

Structural defects become more abundant in green sturgeon embryos exposed to higher temperatures between 17.5°C (63.5°F) and 19°C (66.2°F), while lower temperatures around 11°C (51.8°F) may result in decreased hatching success and the production of smaller embryos (Van Eenennaam et al. 2005). Temperatures in the range of 57° to 62°F appear to be optimal for embryonic development (Van Eenennaam et al. 2005).

Juvenile rearing and emigration

Elevated water temperatures (12 °C (53.6 °F) to 17 °C (62.6 °F)) inhibit the activity of ATPase, an enzyme used by juvenile salmonids to osmoregulate in seawater. Decreased ATPase activity has led to loss of migratory behavior in anadromous juvenile salmonids (reviewed in Richter and Kolmes 2005).

The EPA guidelines recommend water temperatures do not exceed 61°F 7-day average daily maximum (7DADM) for juvenile rearing salmonids in the upper basin of natal rivers and do not exceed 64°F in the lower basin of natal rivers (U.S. Environmental Protection Agency 2003). Potential sub-lethal temperature effects on juvenile salmonids include slowed growth, delayed smoltification, desmoltification, and extreme physiological changes, which can lead to disease and increased predation. Salmonids co-evolved with predators such as pikeminnow (*Ptychocheilus grandis*), but exposure to both elevated water temperatures and limited flow-dependent habitat availability make juvenile salmonids more susceptible to predation (Bratovich et al. 2005; Myrick and Cech 2004; Water Forum 2005). Several studies suggest that the optimal temperature for Chinook salmon growth lies within the 63°F to 68°F range (Brett et al. 1982; Clarke and Shelbourn 1985; Marine and Cech 2004; Myrick and Cech 2004; Myrick and Cech Jr 2002). Increased food consumption rates and energy demands have been observed in juvenile green sturgeon at higher temperatures between 11 °C (51.8 °F) and 15 °C (59 °F) (Mayfield and Cech 2004). Juvenile sturgeon can tolerate higher temperatures and optimal bioenergetics performance was found to be between 59 to 66°F ((Mayfield and Cech 2004); (Table 16)).

Adult migration, holding and spawning

Salmonids with a stream life history, such as spring-run Chinook salmon and steelhead, need suitable spawning and rearing temperatures to be maintained year round. The larger salmonid juvenile life stages are less sensitive to temperature than the alevins and yolk-sac fry, but will suffer lethal and sub-lethal effects when not in optimal instream temperatures.

Adult salmonid migrations have been blocked by temperatures ranging from 19 °C (66.2 °F) to 23 °C (73.4 °F) (reviewed in Richter and Kolmes 2005). Delayed migrations can alter the timing of spawning events. The effectiveness of adult salmonid gametes can be compromised if exposed to temperatures above 13 °C (55.4 °F), and direct mortality of salmonids can occur if exposed to temperatures above 26 ° C (78.8 °F) (reviewed in Richter and Kolmes 2005). Pre-spawning mortality in salmonids appears to be strongly correlated with extended holding in warmer freshwater (Keefer et al. 2010). The dissolved oxygen available for fish decreases with increasing water temperature. Green sturgeon exhibit high dissolved oxygen consumption rates under normal conditions and require large dissolved oxygen concentrations to avoid stress (reviewed in Israel and Klimley 2008).

Adult green sturgeon occupy estuaries when water temperatures range from 14.5 °C (51.8 °F) to 20.8 °C (69.4 ° F) (Moser and Lindley 2007). Suitable spawning temperatures must remain below 63°F to minimize sub-lethal and lethal effects to green sturgeon ((Poytress et al. 2015), Table 16).The threat posed to sDPS green sturgeon by altered water temperatures due to impoundments was ranked high in the Sacramento River Basin for eggs and juveniles. Impoundments alter flow regimes, which in turn affect the water temperature of the river downstream of the impoundment. If water released from the impoundments results in water temperatures that are not within the optimal thermal window for development, survival and growth will be limited.

Table 16. Ranges of water temperatures that support for life-stages of Chinook salmon, steelhead, and green sturgeon.

	Egg/Alevin Incubation	Juvenile	Smolt Migration	Adult Migration	Spawning Initiation
Chinook salmon	43-54°F [a,b]	54-66°F [c,f]	55 - 61°F [j]	38-64°F [k, l, m]	42-57°F [q]
	55°F 7DADM[r]	61°F 7DADM[r]	68°F 7DADM[r]	68°F 7DADM[r]	55°F 7DADM[r]
Steelhead	45-52°F [c,d]	45-69°F [d,g]	54-55°F [c]	39-66°F [n]	39-52°F [d]
	55°F 7DADM[r]	61°F 7DADM[r]	57°F 7DADM[r]	68°F 7DADM[r]	55°F 7DADM[r]
Green sturgeon	57-68°F [e]	59-66°F [h,i]	NA	49-70°F [o, p, q]	49-64°F [o]
	-	-	NA	-	-

Sources: [a] Slater (1963); [b] U.S. Fish and Wildlife Service (1999); [c] Myrick and Cech Jr (2001); [d] IEP (1999); [e] Van Eenennaam et al. (2005); [f] Banks et al. (1971); [g] Myrick and Cech Jr (2005); [h] Mayfield and Cech (2004); [i] Allen et al. (2006); [j] Myrick and Cech (2004); [k] Spence et al. (1996); [llll] Goniea et al. (2006); [m] McCullough (1999); [n] Keefer et al. (2009); [o] Poytress et al. (2015); [p] Kelly et al. (2007); [q] Reiser and Bjornn (1979); [r] 7DADM = seven day average daily maximum

8.1.3 Water Quality

Survival and growth of fish can be impacted by the quality of water in which they live. Water quality encompasses the physical, chemical, and biological properties of aquatic environments. Physical properties include temperature, turbidity, and dissolved gases. Chemical properties include pH, hardness, organic and inorganic contaminants, and metals. Biological properties include pathogens, fishes, insects, algae, and other organisms. The water quality stressor discussed below focuses on threats from contaminants and lowered dissolved oxygen.

8.1.3.1 Contaminants

Chemical forms of water pollution are a major cause of freshwater habitat degradation worldwide. There are many sources of contaminants, and these reflect past and present human activities and land use (Scholz and McIntyre 2015). Contaminants are typically associated with areas of urban development, agriculture, or other anthropogenic activities (e.g., mercury contamination as a result of gold mining or processing). Organic contaminants from agricultural drain water, urban and agricultural runoff from storm events, and high trace element (i.e., heavy metals) concentrations may deleteriously affect early life-stage survival of fish. Persistent organic pollutants such as PCBs disrupt immune system function in exposed fish, thereby rendering exposed fish more susceptible to disease. PCBs are considered persistent pollutants because they resist degradation in the environment, by processes that are either biotic (e.g., microbial breakdown) or abiotic (e.g., photolysis in response to sunlight). They accumulate in sediments and can be resuspended and redistributed in aquatic habitat by dredging and similar forms of human disturbance.

Alterations of flow can also effect related water quality measures (e.g. salinity, sediment, nutrients, metals, and phytoplankton growth) (Cloern and Jassby 2012). These hydrologic alterations can impact the fate and transport of pollutants (e.g. sequestering or resuspending, diluting or concentrating, and increasing or decreasing bioavailability). The resulting toxicity can kill or impede fish (e.g. degrading movements essential to predator avoidance, reproduction, social behaviors, or migration). Zones of degraded water quality, such as chemical or thermal plumes or hypoxic zones without adequate zones of passage (Environmental Protection Agency 2014), can impede fish movement (Giattina and Garton 1983; Scott and Sloman 2004; Sprague and Drury 1969).

If bioaccumulative contaminants such as organochlorines are resuspended from sediments into the water column, they can biomagnify in aquatic food webs. That is, they become proportionately more concentrated at higher trophic levels. Consequently, they present a greater risk to fish that feed at or near the top of aquatic food webs. Exposure to contaminated food sources and bioaccumulation of contaminants from feeding on them may create delayed sublethal effects that negatively affect the growth, reproductive development, and reproductive success of listed anadromous fishes, thereby reducing their overall fitness and survival (Laetz et al. 2009). The effects of bioaccumulation are of particular concern as pollutants can reach concentrations in higher trophic level organisms (e.g., salmonids) that far exceed ambient environmental levels (Allen and Hardy 1980).

Bioaccumulation may therefore cause delayed stress, injury, or death as contaminants are transported from lower trophic levels (e.g., benthic invertebrates or other prey species) to predators long after the contaminants have entered the environment or food chain. Many contaminants lack defined regulatory exposure criteria that are relevant to listed salmonids and yet may have effects on salmonids (Ewing 1999). It follows that some organisms may be negatively affected by contaminants while regulatory thresholds for the contaminants are not exceeded during measurements of water or sediments.

The most common sublethal endpoints in aquatic organisms are behavioral (e.g., swimming, feeding, attraction-avoidance, and predator-prey interactions), physiological (e.g., growth, reproduction, and development), biochemical (e.g., blood enzyme and ion levels), and histological changes (Rand 1995). Some sublethal effects may result in indirect mortality, for example, when a fish already stressed due to toxicity encounters an additional stressor and the combination of those causes death. Changes in certain behaviors, such as swimming or olfactory responses, may diminish the ability of listed fish to find food or escape from predators and may ultimately result in death. Some sublethal effects may have little or no long-term consequences to the fish because they are rapidly reversible or diminish and cease with time. Individual fish of the same species may exhibit different responses to the same concentration of toxicant. In addition, the individual condition of the fish can significantly influence the outcome of the toxicant exposure. Fish with greater energy stores will be better able to survive a temporary decline in foraging ability or have sufficient metabolic stores to swim to areas with better environmental conditions. Fish that are already stressed are more susceptible to the deleterious effects of contaminants and may succumb to toxicant levels that are considered sublethal to a healthy fish.

Exposure to sublethal levels of contaminants has been shown to have serious implications for salmonid health and survival. Studies have shown that low concentrations of commonly available pesticides can induce significant sublethal effects on salmonids. Scholz et al. (2000) and Moore and Waring (1996) have found that diazinon interferes with a range of physiological biochemical pathways that regulate olfaction, negatively affecting homing, reproductive, and anti-predator behavior of salmonids. Waring and Moore (1997) also found that the carbofuran had significant effects on olfactory mediated behavior and physiology in Atlantic salmon (*Salmo salar*). Scientific literature on the effects of pesticides on salmonids have identified a wide range of sublethal effects such as impaired swimming performance, increased predation of juveniles, altered temperature selection behavior, reduced schooling behavior, impaired migratory abilities, and impaired seawater adaptation (Baldwin et al. 2009; Ewing 1999; Laetz et al. 2009; Laetz et al. 2013; McIntyre et al. 2012; Sandahl et al. 2007). Other non-pesticide compounds that are common constituents of urban pollution and agricultural runoff also have the potential to negatively affect salmonids.

Green sturgeon are expected to be more vulnerable than salmonids to sediment contamination due to their benthic-oriented behavior, which conceivably put them in closer proximity to the contaminated sediment horizon, although it is presently unclear if juveniles exhibit this behavior to the same extent that adults do (Presser and Luoma 2010b; Presser and Luoma 2013). Their "inactive" resting behavior on substrate may potentially put them in dermal contact with contaminated sites, which can lead to lesions and the production of tumors from materials in the substrate. Sturgeon are also benthic invertebrate feeders that forage on organisms that can sequester contaminants at much higher levels than the ambient water or sediment content, such as the Asian clams *Corbicula* and *Potamocorbula* that are prevalent in the action area, a non-native species known to bioaccumulate selenium (California Department of Fish and Game

2002; Linville et al. 2002). Laboratory research has revealed that green sturgeon are highly sensitive to selenium with potential impacts including reduced growth and organ abnormalities (Bakke et al. 2010; De Riu et al. 2014; Lee et al. 2011; Silvestre et al. 2010).

The great longevity of sturgeons also places them at risk for the bioaccumulation of contaminants to levels that create physiologically adverse conditions within the body of the fish. Contaminants could also negatively affect the reproductive capacity of female adults during spawning. In addition, pyrethroid insecticides used in crop protection and home pest control may affect aquatic invertebrates and the prey base of the green sturgeon. A recent Biological Opinion found that the pesticides chlorpyrifos, diazinon, and malathion jeopardize green sturgeon and adversely modify their critical habitat (National Marine Fisheries Service 2017a). These pesticides were found to potentially cause direct mortality, impaired behavior, and a reduced prey base (National Marine Fisheries Service 2017a).

8.1.3.2 Dissolved Oxygen

Oxygen is the crucial final electron acceptor in the Krebs Cycle energy-producing pathway, but despite efficient physiological mechanisms for obtaining and using oxygen, it is often a limiting factor for fish who spend considerable energy in perfusion, ventilation, and/or locomotion to extract dissolved oxygen from dense and viscous water (Kramer 1987). In order to avoid suffocation, fish can potentially compensate for hypoxia behaviorally with increases in air or surface breathing or changes in activity or habitat use (Breitburg 2002). Dissolved oxygen impacts on all fish lifestages, including eggs, juveniles, and adults. The embryonic stage is particularly vulnerable due to their immobility, as studies depriving salmon eggs of adequate oxygen observed deformities, premature hatching or delay in emergence, smaller and weaker sac fry, and death (Alderdice et al. 1958; Geist et al. 2006; Silver et al. 1963). Reductions in swimming performance and preference/avoidance behavior can trigger adverse effects on fish, for example migrating adult Chinook exhibited an avoidance response when dissolved oxygen was below 4.2 mg/L and most waited to migrate until dissolved oxygen levels were at 5 mg/L or higher (Bjornn and Reiser 1991; Carter 2005; Hallock et al. 1970).

8.1.3.3 Turbidity

Elevated turbidity and suspended sediment levels have the potential to adversely affect salmonids during all freshwater life stages. Specifically increased turbidity can clog or abrade gill surfaces, adhere to eggs, hamper fry emergence (Phillips and Campbell 1961), bury eggs or alevins, scour and fill in pools and riffles, reduce primary productivity and photosynthesis activity (Cordone and Kelley 1961), and affect intergravel permeability and dissolved oxygen levels (Lisle and Eads 1991; Zimmermann and Lapointe 2005).

Fish behavioral and physiological responses indicative of stress include: gill flaring, coughing, avoidance, and increased blood sugar levels (Berg and Northcote 1985; Servizi and Martens 1992). Excessive sedimentation over time can cause substrates to become embedded, which reduces successful salmonid spawning and egg and fry survival (Waters 1995). Changes in turbidity and suspended sediment levels associated with water operations may negatively impact fish populations temporarily when deposition of fine sediments fills interstitial substrate spaces in food-producing riffles, reducing the abundance and availability of aquatic insects and cover for juvenile salmonids (Bjornn and Reiser 1991). Suspended solids and turbidity generally do not acutely affect aquatic organisms unless they reach extremely high levels (i.e., levels of suspended solids reaching 25 mg/L). At these high levels, suspended solids can adversely affect the physiology and behavior of aquatic organisms and may suppress photosynthetic activity at the base of food webs, affecting aquatic organisms either directly or indirectly (Alabaster and Lloyd 1980; Lloyd 1987; Waters 1995).

Increased sediment concentrations can also affect fish by reducing feeding efficiency or success and stimulating behavioral changes. Sigler et al. (1984) found that turbidities between 25 and 50 nephelometric turbidity units reduced growth of juvenile coho salmon and steelhead, and Bisson and Bilby (1982) reported that juvenile coho salmon avoid turbidities exceeding 70 nephelometric turbidity units. Turbidity likely affects Chinook salmon in much the same way it affects juvenile steelhead and coho salmon because of similar physiological and life history requirements between the species. Newcombe and Jensen (1996) also found increases in turbidity could lead to reduced feeding rate and behavioral changes such as alarm reactions, displacement or abandonment of cover, and avoidance, which can lead to increased predation and reduced feeding. At high suspended sediment concentrations for prolonged periods, lethal effects can occur.

Increased turbidity can also provide a level of cover from predators for outmigrating juveniles and contribute to higher levels of juvenile survival. Turbidity has been shown to reduce the risk of predation and improve the survival of emigrating Pacific salmon in many rivers (Gregory and Levings 1998). For example, Cada et al. (1997) reviewed evidence that reduced turbidity associated with impoundment-related reductions in river velocity was correlated with lower survival of migrating juvenile Pacific salmon in the Columbia River basin. Several other studies have reported significant positive correlations between juvenile salmonid survival and river flow (e.g., (Hosmer et al. 1979; Hvidsten and Hansen 1988).

8.1.4 Water Flow

During the development of the Recovery Plan for Central Valley Chinook Salmon and Steelhead (National Marine Fisheries Service 2014b), flow conditions was identified as a primary stressor affecting the recovery of the species. This threat primarily affects the adult immigration and staging (with Lower Sacramento River low flows for attraction and migratory cues, and flood flows for non-natal area attraction, as well as in the middle and upper Sacramento River low flows for attraction and migratory cues), spawning and egg incubation (with upper Sacramento River flow fluctuations), and juvenile rearing and outmigration (with changes in Delta hydrology, diversions into the central Delta, reverse water flow in the Delta, flow dependent habitat availability in the lower Sacramento River, flow dependent habitat availability in the middle and upper Sacramento River).

Effects of the action that contribute to the water flow are likely to result in a probable change in fitness aspects of: growth, survival probability, reproductive success and/or lifetime reproductive success. Flow conditions here refer to the quantity, timing, and quality of water flows required to sustain fishes and the ecosystems upon which they depend. The discussion below focuses on the following specific facets: hydrologic alteration, redd dewatering, isolation and stranding, travel time and outmigration, and delta survival.

The multi-agency SAIL synthesis teams also identified the relevant pathways by which flow conditions are likely to affect species as well as how it is likely to interact with other stressors.

Specifically, Windell et al. (2017) focused on the impacts of flow to migration, spawning, and growth. The authors discuss how flows impact: migration (by altering contaminant concentration, reducing water temperatures, thereby affecting dissolved oxygen, food availability, predation, pathogens, and disease), entrainment and stranding risk, and cues to stimulate outmigration. They also discuss how low flow can diminish natural channel formation, alter food web processes, slow regeneration of riparian vegetation, reduce bedload movement causing gravels to become embedded, and decrease channel width due to incision, all of which can decrease the availability and variability of spawning and rearing habitat. Additionally, low flows can weaken fish during periods of holding prior to spawning by concentrating fish within a smaller habitat area, thereby increasing the potential for lateral transmission of disease and pre-spawn mortality; while high flows can move weakened fish downstream out of the temperature-controlled section of river, reducing spawning success, or laterally to the stream margins, making them more vulnerable to predation, harassment, or poaching. Finally, the synthesis notes that juvenile salmon growth is influenced by water temperature and access to floodplain habitats – both of which are strongly related to flow.

8.1.4.1 Hydrologic Alteration

The natural flow regime of a water body is defined by its flow magnitude, timing, duration, frequency, and rate of change (Poff et al. 1997). Anthropogenic flow modifications are ubiquitous in running waters, and tend to be most aggressive in locations with highly variable flow regimes, like California, where water storage and flood control is most needed (Dudgeon et al. 2006). Across the major basins of California's Central Valley, mean monthly flows have been depleted from the natural flow regime at 80 percent or more of gauges (Zimmerman et al. 2018). These changes in flow can have cascading effects that alter geomorphology (channel incision, widening, bed armoring, etc.) and connectivity (laterally with the flood-plain, longitudinal upstream-downstream, or vertically between surface water and groundwater) – ultimately impacting the chemical, physical, and biological properties of the ecosystem (Novak et al. 2016).

Literature reviews have shown that fish abundance, diversity and demographic rates consistently decline in response to both elevated and reduced flow magnitude (Poff and Zimmerman 2010). Changes in abundance in the Delta and estuary of juvenile Central Valley Chinook salmon appear related to flow (Brandes and McLain 2001) with recruitment in San Joaquin River Basin being highly correlated with the magnitude and duration of spring flows when the fish were sub-yearling juveniles (Sturrock et al. 2015). Studies in the Southern Sacramento-San Joaquin Delta observed that fish communities at each river location were consistently different each year, and correlated with river flow and turbidity (Feyrer and Healey 2003).

Flows may also be a migration cue for green sturgeon, so altered flows could impact adult in or out migration. Flows could also impact the number of deep pools in the river as well as those with specific characteristics (possibly including flow) that are necessary for spawning. Flow is also likely important for egg development and larval dispersal, but specific, appropriate flow rates are not determined. Reduced spring flows could negatively impact recruitment, given the likely relationship between high spring flows and high green sturgeon recruitment seen in 2006 (Heublein et al. 2017). Successful spawning in the Feather River has also been linked to high spring flows (2011 and 2017; (Heublein et al. 2017). Within the San Francisco Bay Delta Estuary, channel control structures, impoundments, and upstream diversions are recognized as specific threats that have altered and impacted juvenile and subadult/adult green sturgeon.

Localized flow patterns can impact habitat quality for green sturgeon and flow may impact migration and movement.

8.1.4.2 Redd Dewatering

Redd dewatering is a risk to incubating salmonid eggs and alevins. Salmonid redds require cool, oxygenated, low turbidity water for approximately three to four months to complete the egg-alevin life stages (Williams 2006). Water must move through a redd at a swift enough velocity to sweep out fine sediment and metabolic waste. Otherwise, incubating eggs do not receive sufficiently clean, oxygenated water to support proper development (Vaux 1968). Salmonid redd dewatering can occur when water levels decrease after redd construction, exposing buried and otherwise submerged eggs or alevins to air. Dewatering can affect eggs and alevins in multiple ways. Studies have shown that dewatering can impair egg and alevin development and cause direct mortality due to desiccation, insufficient oxygen levels, waste metabolite toxicity, and thermal stress (Becker and Neitzel 1985; Reiser and White 1983).

Dewatering of green sturgeon spawning areas is not a concern because of the location in which eggs are deposited and develop. Green sturgeon spawning primarily occurs in deep pools containing small to medium sized gravel, cobble or boulder substrate (Klimley et al. 2015a; Klimley et al. 2015b; Poytress et al. 2015). Sturgeon eggs primarily adhere to gravel or cobble substrates, or settle into crevices (Moyle 1995; Poytress et al. 2015; Van Eenennaam et al. 2001) where they incubate for a period of seven to nine days. Newly hatched sturgeon fry remain near the hatching area for 18 to 35 days prior to dispersing (Deng et al. 2002; Poytress et al. 2015; Van Eenennaam et al. 2001).

8.1.4.3 Redd Scour

Streambed scour resulting from high flows is a physical factor that can cause salmonid egg mortality. High flows can mobilize sediments in the river bed causing direct egg mortality, if scour occurs to the depth of the redd egg pocket. Scour can also increase fine sediment infiltration and indirectly decrease egg survival (DeVries 1997). Increased water releases for flood control, and for scheduled pulse flows for geomorphic benefit and salmonid migration cues, may be high enough to mobilize sediments, and scour Chinook salmon and steelhead redds.

8.1.4.4 Isolation and Stranding

Rapid reductions in flow can adversely affect fish. Juvenile salmonids are particularly susceptible to isolation or stranding during rapid reductions in flow. Isolation can occur when the rate of reductions in stream flow inhibits an individual’s ability to escape an area that becomes isolated from the main channel or dewatered (U.S. Fish and Wildlife Service 2006). The effect of juvenile isolation on production of Chinook salmon and steelhead populations is not well understood, but isolation is frequently identified as a potentially important mortality factor for the populations in the Sacramento River and its tributaries (Jarrett and Killam 2014; Jarrett and Killam 2015; National Marine Fisheries Service 2009b; U.S. Bureau of Reclamation 2008; U.S. Fish and Wildlife Service 2001; Water Forum 2005).

Juveniles typically rest in shallow, slow-moving water between feeding forays into swifter water. These shallower, low-velocity margin areas are more likely than other areas to dewater and become isolated with flow changes (Jarrett and Killam 2015). Accordingly, juveniles are most vulnerable to isolation during periods of high and fluctuating flow when they typically move into inundated side channel habitats. Isolation can lead to direct mortality when these areas drain or dry up or to indirect mortality from predators or rising water temperatures and deteriorating water quality.

8.1.4.5 Travel Time and Outmigration

Patterns of anadromous fish migration are influenced by a number of variables, including flow velocity, direction, volume, and source. When velocities along migratory corridors are reduced, juvenile outmigration takes longer and smolts are more likely to be vulnerable to increased predation risk (Anderson et al. 2005; Cavallo et al. 2013; Muthukumarana et al. 2008). The amount of time outmigrating juvenile salmonids spend traveling through migratory corridors in the Delta is one indicator of predation risk, with longer travel time through the Delta often resulting in higher mortality rates.

8.1.5 Entrainment

Entrainment is defined as the redirection of fish from their natural migratory pathway into areas or pathways not normally used. Entrainment also includes the take, or removal, of juvenile fish from their habitat through the operation of water diversion devices and structures such as siphons, pumps and gravity diversions (National Marine Fisheries Service 2014b). This threat primarily affects the juvenile rearing and outmigration life stage of species.

And while quantification of the effect of small unscreened diversions is limited, there is no doubt that at times large numbers of juvenile salmonids are entrained by diversions, especially by large and small diversions on tributaries important for spawning and rearing (Moyle and Israel 2005). NMFS fish screen criteria (National Marine Fisheries Service 1997a; National Marine Fisheries Service 2011e) intended to limit entrainment for waters which may contain salmonid fry (less than 60 mm in total length), identifies a maximum gap between bars of 0.069 in. (1.75 mm). Screens of these dimensions are designed to minimize the entrainment of alevins, fry, juvenile, and larger salmonids. Juvenile fish with a head width of less than or slightly greater than 1.75 mm have the potential to pass through screen openings and get entrained into the diversions. It is possible that juvenile fish with heads larger than the 1.75 mm screen openings may pass through the fish screen if they become impinged on the fish screen and, during the process of trying to free themselves, change their orientation and are pulled through the fish screen openings by the current passing through the slot openings of the fish screen. Since ossification of the bones is not yet complete during the early life stages of teleost fish (Mork and Crump 2015; Van den Boogaart et al. 2012; Witten and Hall 2015), the plasticity of the cranium, opercular, and axial skeletal structures of larvae and fry may allow these otherwise bony structures to deform, allowing the fish to pass through a screen. Also, juvenile fish that exceed the minimum size criteria for exclusion and that are impinged on the fish screen may pass through the fish screen if they are pushed through by screen cleaner brushes (ICF International 2015). It is expected that all fish entrained through a screen would be lost to the population, as an attempt to salvage any of these fish from behind the screens is not expected. These fish are effectively considered as mortalities, even if they survive their entrainment through the screens. Fish screen criteria for larval green sturgeon have not been developed.

Impingement may occur when the approach velocity exceeds the swimming capability of a fish, creating substantial body contact with the surface of a fish screen. Whether or not impingement would occur depends on screen approach velocity, screen sweeping velocity, and the swimming capacity of juvenile fish. Injury resulting from impingement may be minor and create no long-term harm to the fish, or result in injuries leading to mortality either directly or at some time in the future after contact with the screen, including predation or infections from wounds and abrasions associated with the screen contact. Approach velocity is the vector component of the channel's water velocity immediately adjacent to a screen face that is perpendicular to and upstream of the vertical projection of a screen face, calculated by dividing the maximum screened flow by the effective screen area. Fish screens with approach velocities less than or equal to 0.33 ft/sec would minimize screen contact and impingement of juvenile salmonids (National Marine Fisheries Service 1997a). Sweeping velocity is the vector component of channel flow velocity that is parallel and adjacent to the screen face, measured as close as physically possible to the boundary layer turbulence generated by the screen face. Screening criteria from California Department of Fish and Game (2000) requires a sweeping flow velocity/approach velocity of 2:1 for in river fish screens while National Marine Fisheries Service (2011e) recommends that for screens longer than 6 feet, the optimal sweeping velocity should be at least 0.8 ft/sec and less than 3 ft/sec, with sweeping velocity not decreasing along the length of the screen. These criteria are such that they will reduce exposure time of fish to a screen and therefor the potential for impingement as fish move past it.

Juvenile green sturgeon (350-mm mean fork length) appear to lack avoidance behavior when encountering unscreened water-diversion structures (Mussen et al. 2014). In this study sturgeon entrainment ranged from 26 to 61 percent and they estimated green sturgeon entrainment of up to 52 percent if they passed within 5 ft of an active diversion three times. The studies examined the rate of entrainment with different intake flows through the pipe inlet and sweeping flows past the unscreened diversions, where there did not appear to be significant differences in the entrainment risk at different sweeping velocities of 0.4, 1.2, and 2.0 ft/s. However, there was a trend towards less entrainment at higher sweeping flows, which appeared to be related to the swimming behavior of the experimental fish. At lower sweeping flows, fish were more actively swimming, and thus encountered the inlet to the pipe more frequently. In contrast, very low numbers of sturgeon were entrained in a monitoring project that sampled 12 unscreened diversions (<150 cfs) on the Sacramento River between Colusa and Knights Landing (Vogel 2013). During Vogel's study, green sturgeon were entrained at the South Steiner diversion during the irrigation seasons in 2010 (n=3 [extrapolated]; FL = 86 mm; approach velocity = 2.17 ft/sec) and 2011 (n=1; FL = 70 mm; approach velocity = 0.08 ft/sec); and at the Tisdale diversion in 2011 (n=1; FL = 106 mm; approach velocity = 0.40 ft/sec) but not in the 2012 (n=0) irrigation season.

8.2 Beneficial Conservation Measures

Conservation actions can improve the production, growth, and survival of fish depending on the specific type of measure that is implemented. Spawning gravel augmentation can improve the amount of spawning habitat in a river and can result in increased egg and juvenile production, which, in turn can increase juvenile and adult abundance; side channel restoration can improve growth and survival of juveniles which can also result in higher levels of production and juvenile and adult abundance; spring pulse flows can improve rearing and migration survival by increasing cover from predation and increase aquatic food availability, which can also increase juvenile and adult abundance; channel maintenenace flows can support processes that maintain and create habitat features such as spawing habitat, gravel bars, riparian habitat, pool formation and other processes that are necessary to support different life history stages in a stream or river system; fish passage improvements assist both adults and juvenile migration to upstream holding and spawning habitats or to downstream rearing sites and migration corridors.

8.3 Upper Sacramento/Shasta Division

NMFS deconstructed the proposed action to identify the project components (Figure 38) that would create stressors that may affect listed species (Table 17). The exposure, risk, and response of each species to the project-related stressors are then analyzed in the following sections for each proposed action component.

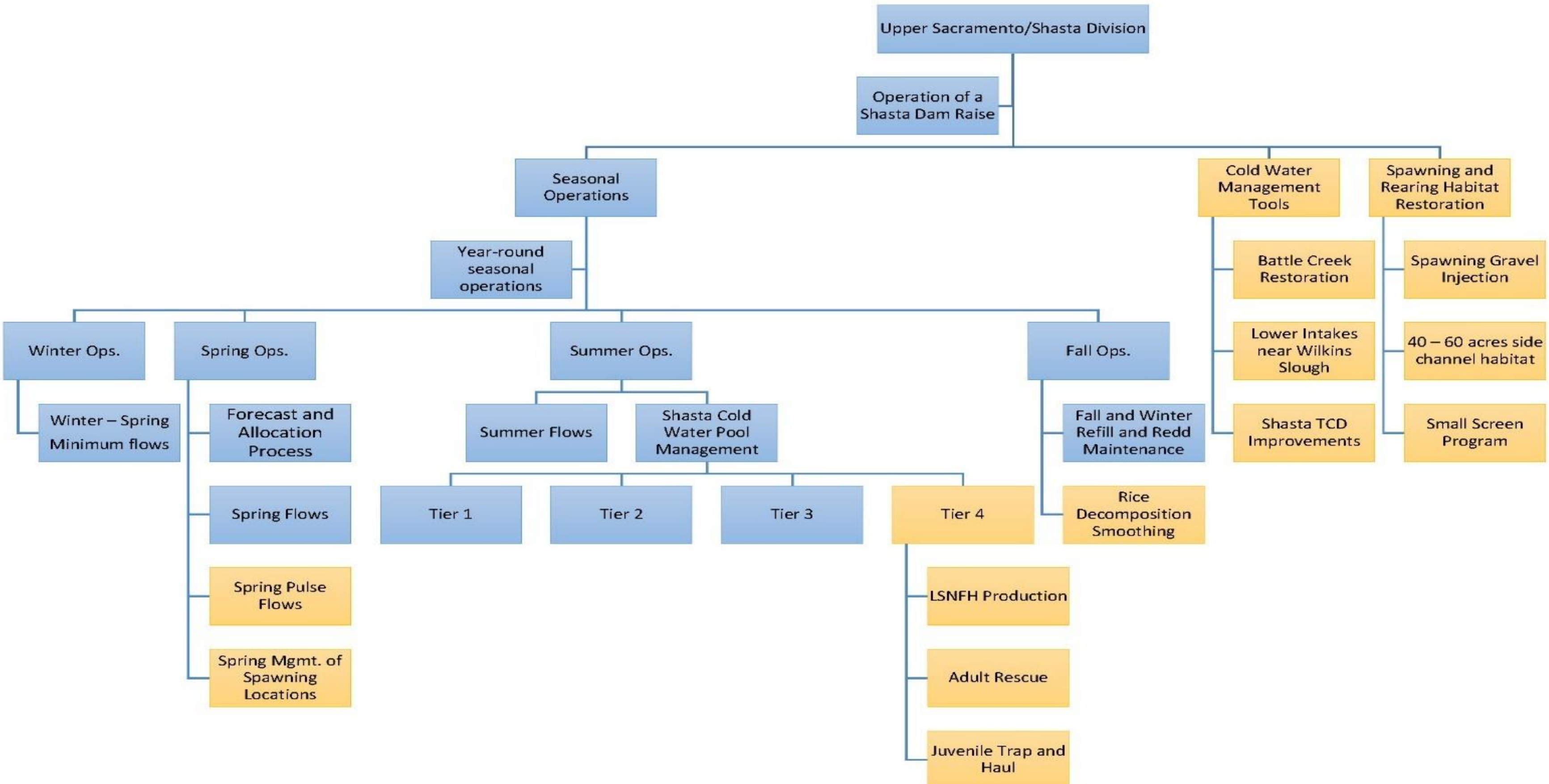


Figure 38. Deconstructed project components in the Sacramento River.

Table 17. Stressors created by components of the proposed action in the Upper Sacramento/Shasta Division.

Project Component	Passage Impediments/ Barriers	Water Temperature	Water Flow	Entrainment
Winter Minimum flow	-	X	X	-
Spring Base Flow	-	-	-	-
Spring Pulse Flow	X	X	X	-
Spring Mgmt of Spawning Locations	-	X	-	-
Summer Cold Water Pool Management Tiers 1-4	-	X	-	-
Delta Smelt Summer-Fall Habitat	-	X	X	-
Fall and Winter Refill and Redd Maintenance	-	-	X	-
Rice Decomposition smoothing (Fall operations)	-	-	X	-
Operation of a Shasta Dam Raise[8]	-	-	-	-
Battle Creek Restoration (Cold water pool management)	-	-	-	-
Wilkins Slough Intakes (Cold water pool management)	-	X	X	X
Shasta temperature control device Improvements (Cold water pool management)	-	X	-	-
Spawning Gravel Injection (Spawning/rearing habitat restoration)	-	-	-	-
Side-Channel Habitat Restoration (Spawning/rearing habitat restoration)	-	-	-	-
Small Screen Program (Spawning/rearing habitat restoration)	-	-	-	X
Livingston Stone National Fish Hatchery Production (Tier 4 action)	-	-	-	-
Adult Rescue (Tier 4 action)	X	-	-	X
Juvenile Trap and Haul (Tier 4 action)	-	-	-	-

An "X" indicates that the action component affects a stressor category; the response could be negative or positive.

Reclamation operates Shasta and Keswick dams year-round in coordination with the other facilities of the CVP and SWP. Seasonal operations follow a set of objectives. During winter, Reclamation operates for flood control and building storage, considering both the channel capacity within the Sacramento River and Shasta Reservoir flood conservation space. When making 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

[8] The proposed action proposes that operational criteria with the Shasta Dam Raise will be the same as operational criteria for the current dam and integrated CVP/SWP operations. Reclamation has advised NMFS that therefore the BA analyses suffice for purposes of consultation. There are no operational scenarios in the BA to evaluate to confirm beneficial or adverse effects of a raised Shasta Dam and NMFS therefore cannot further evaluate the Shasta Dam raise in this opinion.

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, upstream temperature control, and exports. Fall operations attempt to reduce releases to build storage and provide for fish spawning habitat, while operating for Delta water quality and other project purposes and requirements. Except for diversions needed for rice decomposition, downstream irrigation demands typically decrease during the fall, so during this time of year, Reclamation will operate to conserve storage and decrease Keswick releases in addition to meeting other project requirements and demands, including Delta water quality and requirements.

The proposed action includes several operational components, described in more detail in subsequent sections of this effects analysis that Reclamation intends to implement to contribute to increased spring Shasta Reservoir storage levels for the proposed action compared to recent years. These include (1) targeting minimum late fall and winter flows, including modification of rice decomposition operations compared to the current operations scenario[9]; (2) modified fall outflow requirements in wet years compared to the current operating scenario; (3) flexibility in export operations (especially in April and May) compared to the current operating scenario that reduce the reliance on stored water through summers of drier years, and anticipated improved salinity conditions which would reduce carriage water demands; and (4) December 2018 changes to Coordinated Operations Agreement (which are also included in current operating scenario). Reclamation intends for these operations, as well as real-time operations, to aggregate and result in both increased end of September carryover storage, and the following May 1 storage in years that do not require flood control operations.

8.3.1 Baseline and Without Action Considerations

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 upper Sacramento River. Depending on the timing, location, lifestage, and species affected, these effects can be beneficial, neutral, or adverse, or all three based on which species is being evaluated. For example, a decision to store water in April has an adverse effect in April on CV spring-run Chinook salmon juveniles and a beneficial effect in May through October on winter-run Chinook salmon eggs and emergent fry. NMFS traces and analyzes these effects in this section of the Opinion, often relative to baseline conditions given the nature of modeling outputs and historical data.

The "without action" scenario provides context for how the existence of the CVP and SWP facilities have shaped the environmental baseline, including habitat conditions for species and critical habitat in the action area. In particular, the existence of the dams, an altered hydrograph, and high water temperatures limit suitable spawning habitat. An analysis of changes in hydrographs helps to highlight the significant changes in flows that species experience from these historical conditions. The pre-dam hydrograph in Figure 39 shows that the median monthly

[9] The current operations scenario is a representation of output from the CalSimII model is a generalized water resources modeling system for evaluating operational alternatives of large, complex river basins.

flows would naturally have been quite different than the regulated flows into the upper Sacramento River since 1950. The natural hydrograph peaks during winter and spring months of December through May, which coincides with periods of increased precipitation and warmer-season snowmelt that are typical of the Central Valley climate. In contrast, project-wide requirements, demands and contract deliveries have created a peak in the hydrograph in May through August, with lower flows through winter, spring, and the rest of fall.

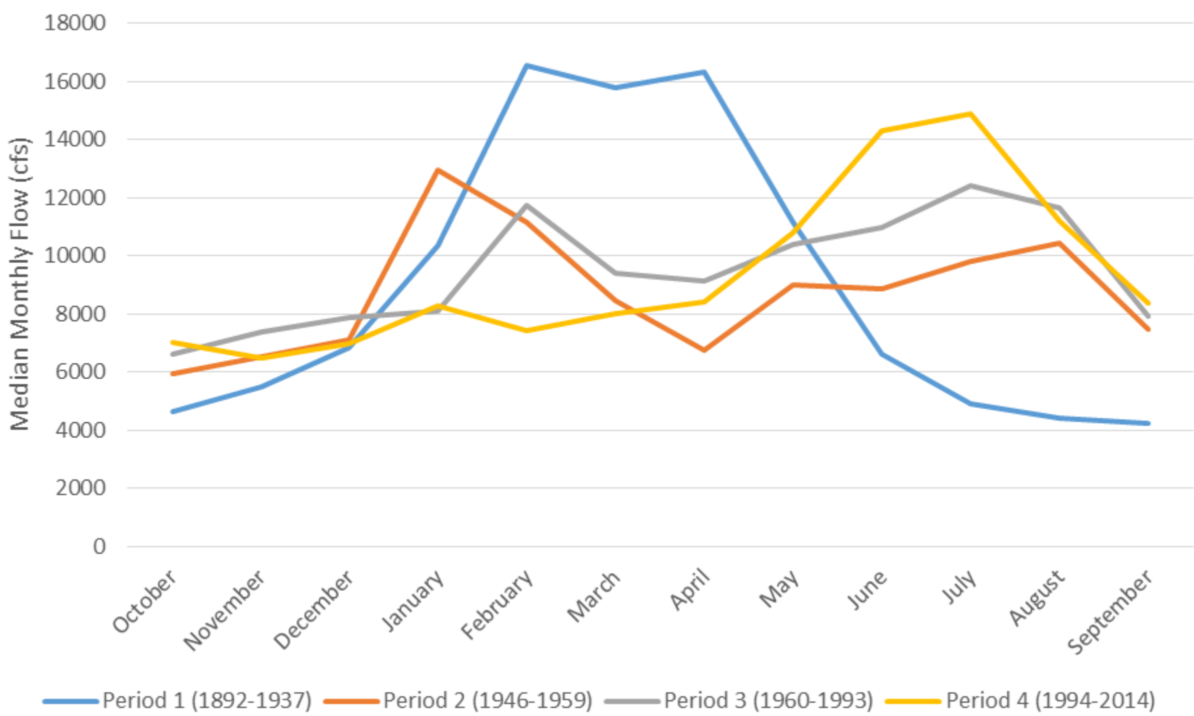


Figure 39. Hydrograph of median monthly flow rate in the Sacramento River for different pre- and post-dam periods at Bend Bridge. Shasta Dam commission: 1944-1945; Keswick Dam commission: 1950.

Source: (Swart 2016)

As previously described, water temperatures significantly affect the distribution, health, and survival of native salmonids in the California Central Valley. Since salmonids are ectothermic (cold-blooded), their survival is dependent on external water temperatures and they will experience adverse health effects when exposed to temperatures outside their optimal range. Salmonids have evolved and thrived under the water temperature patterns that historically existed (i.e., prior to significant anthropogenic impacts that altered temperature patterns) in California Central Valley streams and rivers. In the *EPA Region 10 Guidance for Pacific Northwest State and Tribal Temperature Water Quality Standards*, evidence suggested that historical water temperatures exceeded optimal conditions for salmonids at times during the summer months on some rivers, the temperature diversity in these unaltered rivers provided enough cold water during the summer to allow salmonid populations as a whole to thrive (U.S. Environmental Protection Agency 2003).

Through year-round operations, physical processes drive relationships between flows, storage, cold water pool volume, and water temperatures (both lake 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 that are caused by system-wide regulatory requirement, demands, and all other diversions. Because of the thermal dynamics associated with seasonal stratification in Shasta Reservoir, Reclamation's decisions 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. Before the Shasta Dam temperature control device was built, NMFS required that a minimum 1.9 million acre-feet end of September storage level be maintained to protect the cold water pool in Shasta Reservoir in case the following year was critically dry (i.e., drought year insurance), and continued this requirement after the temperature control device was completed. This was because a relationship may exist between end of September storage and end of May storage (and presumably cold water pool). Especially for drier conditions, greater end of September storage level typically influences greater storage (and presumably cold water pool) in spring of the following year. Since 1997, when the temperature control device became operational, Reclamation has been able to use the temperature control device as an additional means to manage water temperatures in the upper Sacramento River.

It has also become apparent from Shasta operations in the drought years that end of May storage is a critical indicator of the ability tomanage downstream temperatures during summer and early fall. A minimum Shasta storage of approximately 3.9 to 4.1 MAF is necessary access the upper gates of the temperature control device. Use of these gates allows Reclamation to effectively blend water from the warmer upper reservoir levels and thereby reduce reliance on the more limited cold water earlier in the year thereby extending the time period in which coldwater can be provided downstream. Figure 40 shows the general relationship between total storage on May 1st, cold water pool storage, and summer/early fall downstream temperature that has been developed according to analysis done by Reclamation using data from 1998 through 2015 (U.S. Bureau of Reclamation 2019c) (Figure 40). As this figure shows, an end of April storage of at least 3.9 million acre-feet or a coldwater pool greater than 2.6 million acre-feet may be needed to meet a daily average temperature of 53.5°F at the Sacramento River at the Clear Creek gauging station in May-October. This "rule of thumb" chart is used with temperature modeling of measured and forecasted conditions by Reclamation when developing temperature management plans.

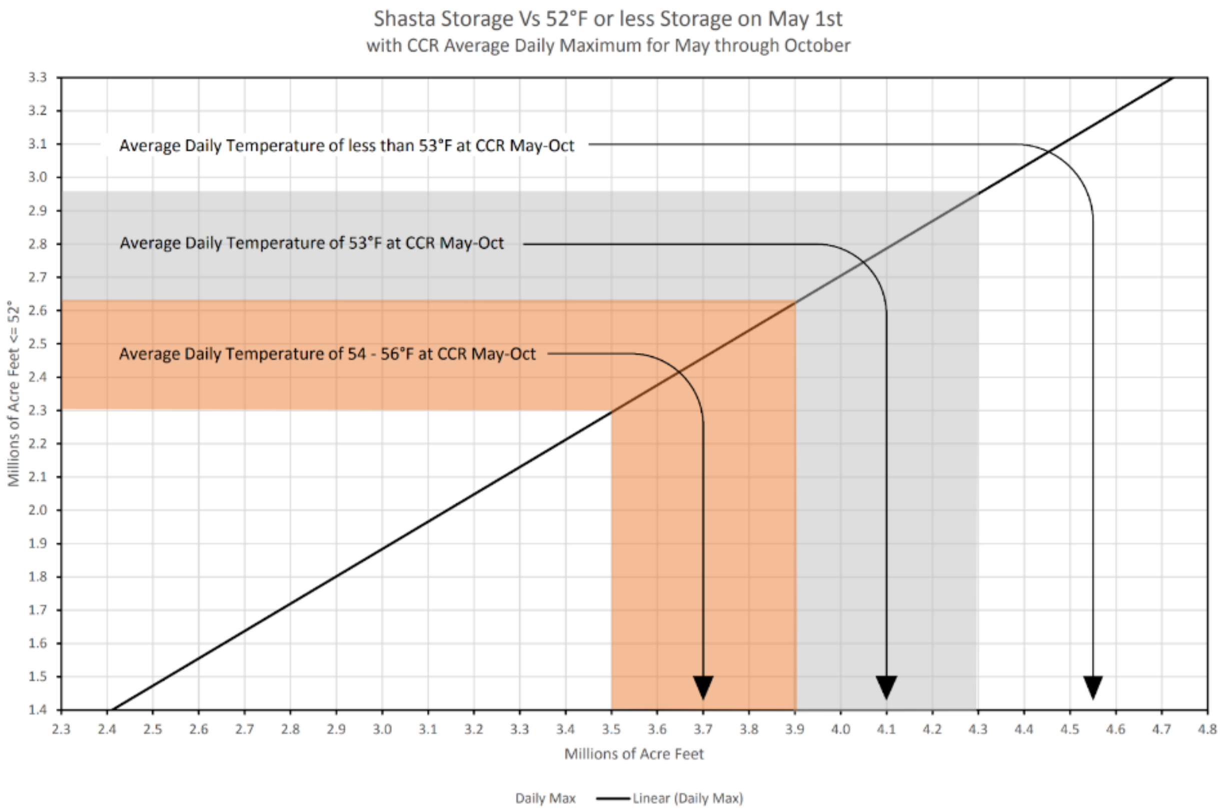


Figure 40. Relationship between temperature compliance, total storage in Shasta Reservoir, and cold water pool in Shasta Reservoir.

Source: ROC on LTO biological assessment Figure 4-2

Recent analyses can be useful to understand effects of changing the flowrate of reservoir releases, which is a method Reclamation considers for controlling temperatures below Shasta Reservoir in order to maintain water temperatures for egg development between Keswick Dam and the Clear Creek gauge. NMFS Southwest Fisheries Science Center (SWFSC) has analyzed the relationship between Clear Creek gauge water temperature and Keswick gauge water temperature and discharge. Using observed mean daily flow and temperature values from 1998 to 2017, a linear model was fit to estimate the monthly relationship between increasing/decreasing flow or temperature at Keswick gauge and water temperature at Clear Creek gauge . The model allows prediction of the effect of a change in Keswick gauge discharge on Clear Creek gauge temperature, assuming a constant flow for a given month. Figure 41 shows the estimated Keswick gauge discharge temperature required to obtain a water temperature less than or equal to 53.5°F at Clear Creek gauge for five Keswick gauge discharge levels. Using this relationship of temperature and flow, it is possible to estimate either the minimum flowrate or the maximum release temperature at Keswick gauge that is required to maintain 53.5°F at Clear Creek gauge in a particular month.

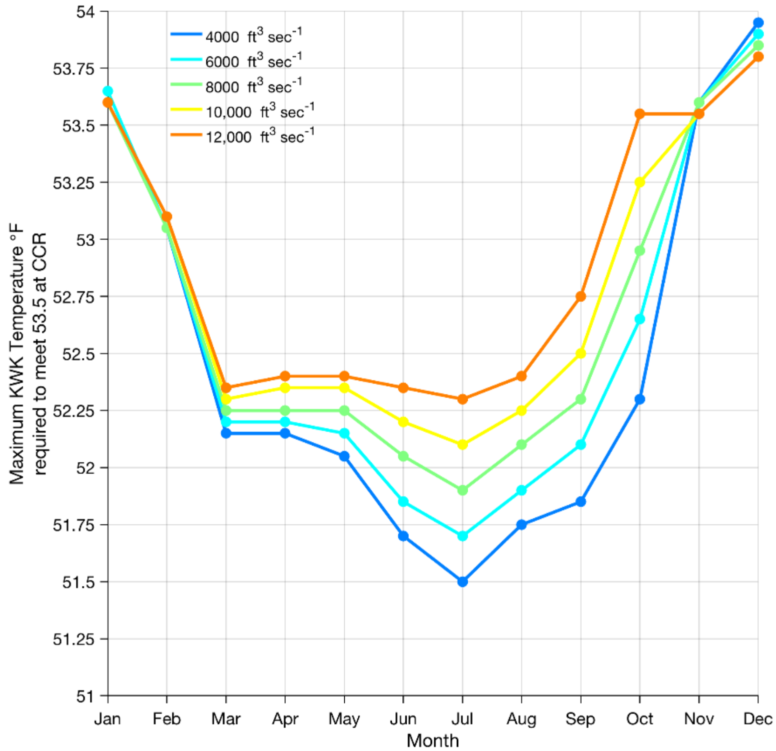


Figure 41. Estimated Keswick Dam discharge temperature required to obtain a water temperature less than or equal to 53.5°F at Clear Creek gauge for five discharge levels.

The recent California drought provides experience to consider in summer temperature management. The critically dry water year of 2014 was followed by a dry 2015, which deepened the drought in California. An already low initial cold water pool volume increased the difficulty of providing suitable cold water temperatures for successful egg and alevin incubation in 2015. In 2015, the Drought Exception Procedures of RPA I.2.3.C of the NMFS 2009 Opinion was triggered. Specifically, the February forecast, based on 90 percent hydrology, showed that a Clear Creek temperature compliance point or 1.9 million acre-feet end of September storage was not achievable. During the development of the temperature management plan, there were regular and frequent check-ins on the status of the cold water pool, storage levels, and temperatures, along with a suite of operational scenarios and Keswick Dam release schedules, which were evaluated by the Sacramento River Temperature Task Group (SRTT) for recommendation to Reclamation. As more information was obtained about the current and developing condition, additional operational scenarios were considered and evaluated, including changes to the amount of storage gained or lost with each Keswick Dam release option, release temperature, and flow rate necessary to meet downstream temperatures while attempting to meet downstream obligations.

Table 4 includes uncertainties related to modeling limitations, alternative analytical tools, and real-time implementation of the proposed action, noting the information provided by Reclamation, and the assumptions we have applied in addressing the uncertainty.

8.3.2 Shasta Winter Operations

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 to 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 mostly 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 non-discretionary exports to exchange contractors, level 2 refuge deliveries, state permit requirements and minimum health and safety exports in the Delta.

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 storage (the proposed action component titled Winter-Spring Minimum Flows). Although Reclamation does not use the phrase "Winter Minimum Flows" in the proposed action or biological assessment to describe Sacramento River conditions during this period, it is used in the Opinion as part of a season-by-season analysis of the effects of the Upper Sacramento/Shasta Division. These base flows consider historical performance in building Shasta Reservoir cold water pool. Table 18 provides Reclamation's example of possible Keswick Dam releases based on Shasta Reservoir storage condition. Reclamation has indicated that it expects to refine this framework through future modeling efforts as part of seasonal operations planning. NMFS expects this table to reflect initial operations and has therefore analyzed effects according to this assumption.

Table 18. Example of December through February Keswick Dam release schedule for various end of September storages.

Keswick Release (cfs)	Shasta End of September Storage (million acre feet)
3,250	≤ 2.2
4,000	≤ 2.8
4,500	≤ 3.2
5,000	> 3.2

Low winter releases would affect in-river water flow and potentially water temperature. There may also be direct effects to redds and rearing fish. Likewise, juveniles rearing at the channel margin can be stranded when flows are lowered. The worst-case scenario for effects to species, in which Keswick Dam releases would be 3,250 cfs in December through February, would apply when end of September is less than or equal to 2.2 million acre-feet. For the proposed action, CalSimII modeling indicates that Shasta end of September storage is less than 2.2 million acre-feet in 20 percent of years. This case would result in a reduction in flows from an average September flow of 6,000 cfs below Keswick Dam to a proposed flow of 3,250 cfs in December to conserve/build storage. This flow reduction would follow the ramping rates included in Reclamation's proposed action. During the precipitation season in the winter, the reduction of Keswick Dam releases may be as great as 50 percent to achieve the proposed flow of 3,250 cfs, but the downstream flow reduction may be a lower percentage due to meteorology and tributary accretions. Effects of these changes to each species is identified below. Relative to the flows of the current operating scenario, CalSimII modeling of the proposed action shows very small differences in monthly average flow. For the period of December 1 to the end of February, the CalSimII modeling of the proposed action shows that Keswick releases are generally expected to provide similar or higher flows in the upper reach of the Sacramento River (ROC on LTO biological assessment Appendix D Table 15-3) except in critical water year types.

8.3.2.1 Winter-Run Chinook Salmon Exposure, Response, and Risk

During the period of winter seasonal operations, from December 1 through the end of February, winter-run Chinook salmon fry have emerged from their redds and the majority of juveniles will have migrated past Red Bluff Diversion Dam. Rotary screw trap data (University of Washington Columbia Basin Research 2019) from the last ten years show that 90 to 95 percent of a brood year's cohort will have migrated past Red Bluff Diversion Dam by December 1 (Figure 42), meaning there is limited potential exposure to the effects of winter minimum flow conditions. With flows during the juvenile rearing period (July-December) averaging 9,000 cfs downstream of Keswick Dam, ramping down of Shasta releases to winter minimum flowsflowsflows pose a stranding risk to juveniles. The greatest stranding risk posed by these operations would occur when September releases are more than 6,000 cfs and releases are reduced to 3,250 cfs by December 1. Stranding risk also increases with proximity to Keswick Dam where flow from tributary accretions are less than downstream reaches. The risk associated with these operations is reflected in the proportion of years that Keswick Dam releases in December would be no greater than 3,250 cfs. Assuming the initial operations reflected in Table 18, CalSimII modeling indicates that end of September storage is less than or equal to 2.2 million acre-feet in about 20 percent of years (ROC on LTO biological assessment Appendix D Table 3-2), and there is therefore a 20 percent probability in any year that December flows would be reduced to 3,250 cfs.

Juvenile stranding generally results from reductions in flow that occur over short periods of time. The analysis uses the monthly flow results provided by CalSimII modeling of proposed action operations, which is too coarse for a meaningful analysis of the short-term drivers of juvenile stranding. Ramping rates for dams on the Sacramento River and its tributaries are expected to remain the same for the proposed action, reservoir releases may vary from year to year in timing of flow fluctuations. The proposed action's nocturnal ramping rates are designed to reduce stranding levels.

Beginning in 2010, CDFW initiated annual surveys in the Upper Sacramento River to monitor redd dewatering and juvenile stranding surveys were initiated in 2013. Between 2013 and 2017, CDFW survey crews observed variable amounts of winter-run Chinook salmon stranding ranging from 181 to 2,143 individuals and identified as many as 269 stranding sites between the Keswick Dam and the Tehama Bridge (a total of 73 river miles) (California Department of Fish and Wildlife 2013b; California Department of Fish and Wildlife 2014b; California Department of Fish and Wildlife 2015b; California Department of Fish and Wildlife 2016b; California Department of Fish and Wildlife 2017b; U.S. Bureau of Reclamation 2015). There is, therefore, uncertainty to 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. For operation of the CVP under the proposed action, NMFS expects that stranding of at least a small proportion of winter-run Chinook salmon juveniles will continue with proposed action implementation and will adversely affect exposed individuals.

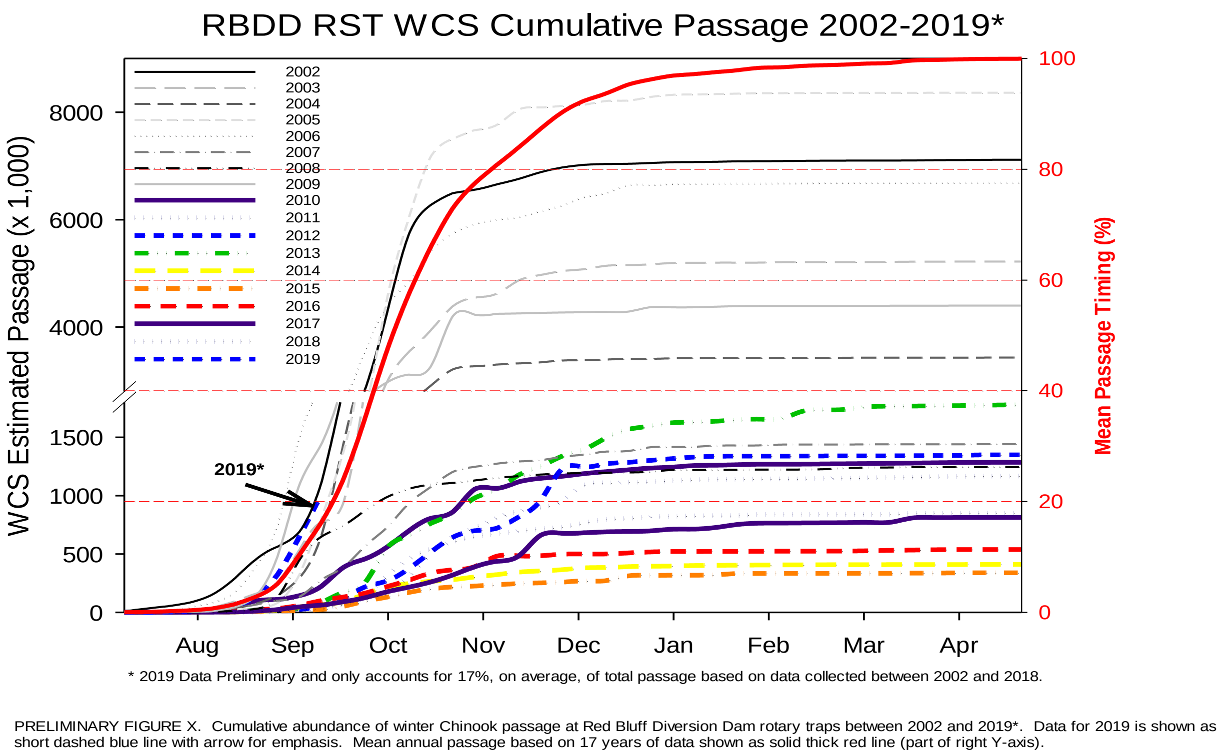
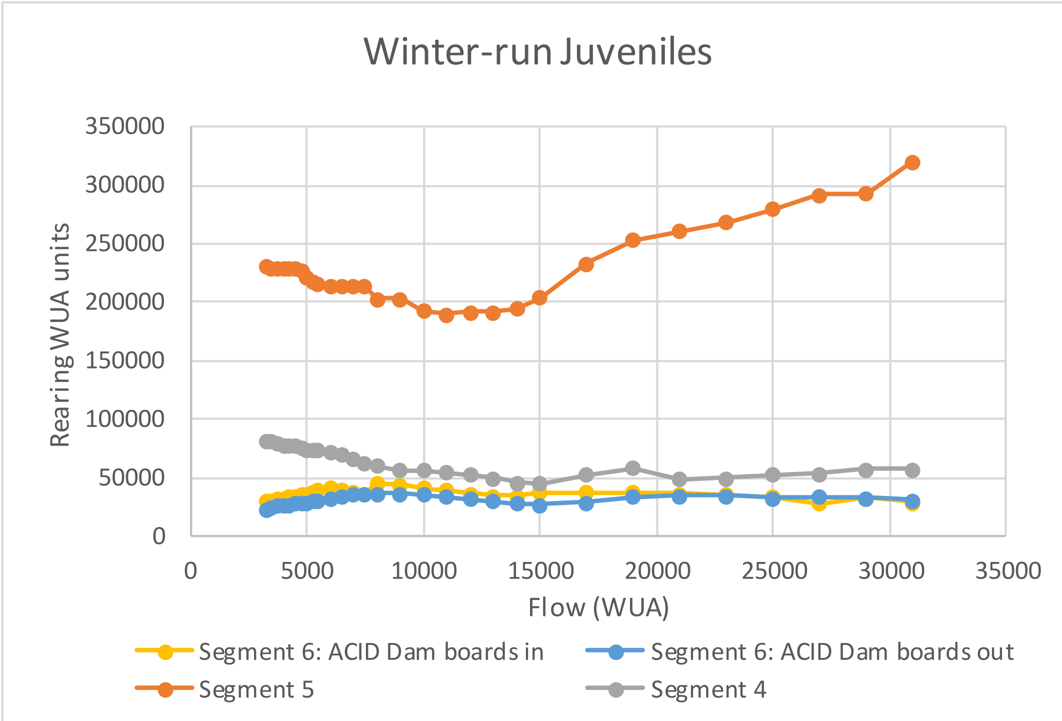


Figure 42. Red Bluff Diversion Dam Juvenile Winter-run Chinook salmon passage data from 2009 to 2017.

Winter-run Chinook salmon rearing habitat weighted usable area analysis in the upper Sacramento River shows that for flows below 12,000 cfs, fry rearing habitat weighted usable area value peaks at about 4,500 cfs and juvenile rearing habitat peaks at about 3,250 cfs for Segment 5 (Cow Creek to the Anderson-Cottonwood Irrigation District Dam). For Segment 4 (Battle Creek to Cow Creek), rearing habitat decreases as flows increase from 3,250 to 15,000 cfs.Weighted usable area curves for Segments 4 and 5 indicate maximum habitat for winter-run Chinook rearing occurs at the lowest flows depicted in Figure 43. In contrast, Segment 6 (Anderson-Cottonwood Irrigation District to Keswick Dam) with the Anderson-Cottonwood Irrigation District Dam boards in or out, the habitat-flow relationship remains relatively static even with increasing flow (Figure 43). Segment 5, the middle reach between Cow Creek and Anderson-Cottonwood Irrigation District, has the greatest weighted usable area values, with upstream (Segment 6) and downstream (Segment 4) reaches providing less habitat area. Since the weighted usable area value is "roughly equivalent to the carrying capacity of a stream reach, based on physical conditions" (Bovee (1978) as cited in Payne (2003)), changes in the weighted usable area value describe the effect of flow and flow changes on the carrying capacity of a reach. A relative decrease in weighted usable area could result in either a reduced quality of rearing or could force rearing fry and juveniles to move out of the habitat in to less ideal condition. For either case, a reduced weighted usable area is expected to lead to reduced growth. In the case of this species, the weighted usable area analysis shows the peak habitat carrying capacity for all upper Sacramento River reaches combined occurs when Keswick releases are approximately 4,500 cfs. This release is within the higher end of the proposed December to February release schedule; greater habitat reductions as measured by weighted usable area occur at flows less than or greater than 4,500 cfs and are expected to occur when operations require flows to be at those lower levels (Figure 43).

With regards to the water temperature stressor, NMFS notes that proposed reduced winter flows at Keswick Dam can contribute to increased spring Shasta Reservoir storage levels for the proposed action relative to recent years. This is expected to increase the available cold water pool and Reclamation’s ability to sustain lower water temperatures during the summer temperature management season.

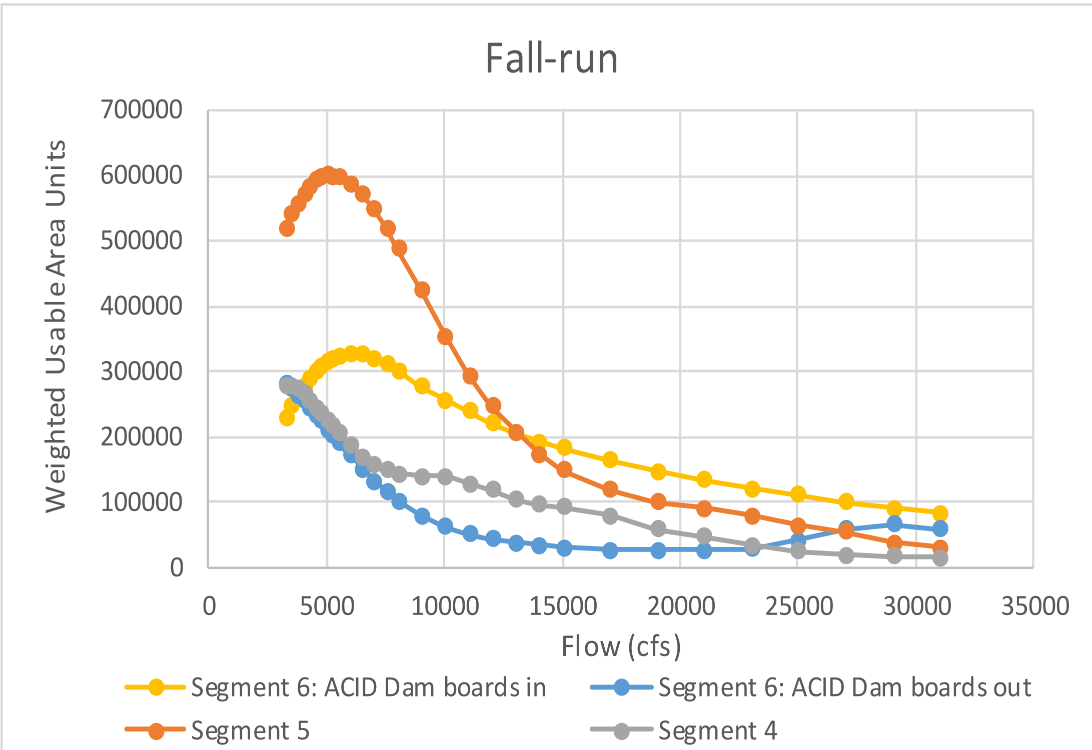


Segment 6 is Anderson-Cottonwood Irrigation District (Anderson-Cottonwood Irrigation District) Dam to Keswick Dam, Segment 5 is Cow Creek to Anderson-Cottonwood Irrigation District Dam, and Segment 4 is Battle Creek to Cow Creek. Figure and information provided by Reclamation.

Figure 43. Juvenile winter-run Chinook salmon rearing weighted usable area/flow relationship (Keswick Dam to Battle Creek).

8.3.2.2 Central Valley Spring-run Chinook Salmon Exposure, Response, and Risk

CV spring-run Chinook salmon begin their emigration from the upper Sacramento River in mid-October. By December 1, an average of 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. Flows during the juvenile rearing period (November through April) average about 8,000 cfs downstream of Keswick Dam, which poses a stranding risk to juveniles when flows are reduced. The greatest risk posed by these operations would occur when December flows are reduced to 3,250 cfs and risk increases with proximity to Keswick Dam due to less tributary accrections. The risk associated with these operations is reflected in the proportion of years that Keswick flows in December would be no greater than 3,250 cfs. Assuming the initial operations reflected in Table 18, CalSimII modeling indicates that end of September storage is less than or equal to 2.2 million acre-feet in about 20 percent of years (ROC on LTO biological assessment Appendix D Table 3-2), and there is therefore a 20 percent probability in any year that December flows would be reduced to 3,250 cfs. Similar to 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. Between 2013 and 2017, CDFW surveys in the Upper Sacramento River observed as many as 19,892 stranded juvenile salmon that are a combination of fall-run, late-full-run and spring-run Chinook salmon (California Department of Fish and Wildlife 2013b; California Department of Fish and Wildlife 2014b; California Department of Fish and Wildlife 2015b; California Department of Fish and Wildlife 2016b; California Department of Fish and Wildlife 2017b). The risk of flow fluctuations in the river reaches below Keswick Dam that can strand CV spring-run Chinook salmon is assumed 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. NMFS expects that stranding of at least a small proportion of CV spring-run Chinook salmon juveniles will continue with proposed action implementation and will adversely affect exposed individuals. The proposed action's nocturnal ramping rates are designed to reduce stranding levels.



Segment 6 is Anderson-Cottonwood Irrigation District Dam to Keswick Dam, Segment 5 is Cow Creek to Anderson-Cottonwood Irrigation District Dam, and Segment 4 is Battle Creek to Cow Creek. Figure provided by Reclamation.

Figure 44. Adult fall-run Chinook salmon spawning weighted usable area/Flow relationship (Keswick Dam to Battle Creek).

Fall-run Chinook salmon weighted usable area analysis is used as a surrogate for CV spring-run Chinook salmon in the upper Sacramento River (Battle Creek to Keswick Dam) (Figure 44). This analysis shows a decreasing spawning habitat weighted usable area value that corresponds to decreasing flow from 6,000 cfs to 3,250 cfs for segments 5 (Cow Creek to the Anderson-Cottonwood Irrigation District Dam) and 6 (Anderson-Cottonwood Irrigation District to Keswick Dam). For segment 4 (Battle Creek to Cow Creek) and for segment 6 with the Anderson-Cottonwood Irrigation District Dam boards out, the habitat flow relationship peaks at the lowest studied flows (3,250 cfs). Overall, this weighted usable area analysis shows a peak spawning habitat carrying capacity for fall-run, and therefore, CV spring-run Chinook salmon, at flows around 5,000 to 6,000 cfs, which is greater than the range proposed as example initial operations in Figure 44. This reduced weighted usable area is expected to lead to reduced spawning area and potentially reduced spawning success.

8.3.2.3 California Central Valley Steelhead Exposure, Response, and Risk

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 adapted by individuals from the same sibling cohort, making determinations regarding run timing difficult. Rotary screw trap data from the last 10 years show that, generally, CCV steelhead begin their emigration from the upper Sacramento River starting in mid-March to early April. During the December-February timing of operations in the Winter Minimum Flows proposed action component, it is likely that many of the steelhead redds and a large proportion of steelhead juveniles will be exposed to the winter water flow and reduced access to riparian habitat. The greatest risk posed by these operations would occur when December flows are reduced to 3,250 cfs. The risk associated with these operations is reflected in the proportion of years that Keswick flows in December would be no greater than 3,250 cfs. Assuming the initial operations reflected in Table 18, CalSimII modeling indicates that end of September storage is less than or equal to 2.2 million acre-feet in about 20 percent of years (ROC on LTO biological assessment Appendix D Table 3-2), and there is therefore a 20 percent probability in any year that December flows would be reduced to 3,250 cfs. The species response to reducing winter flows to 3,250 cfs in the upper Sacramento River would include poorer feeding conditions, increased competition and predation related to less floodplain and side-channel habitat, and reduced emigration while flows are held near minimums. The subsequent increases in the frequency and duration of flood control releases are expected to result in temporary reversal of many of these effects, increasing access to juvenile habitat and improving migration conditions, although they would also increase the potential to strand juveniles and dewater redds spawned during relases as flows recede. However, most steelhead spawning is thought to occur within tributary streams rather than the mainstem of the Upper Sacramento River, so the proportion of redds exposed to flow fluctuations would be limited.

Similar to 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 also persist as operations continue to target lower reservoir releases in the fall and winter to maximize storage. CDFW surveys in the Upper Sacramento River have observed stranded *O. mykiss* (combination of steelhead and resident rainbow trout) and 373 stranded *O. mykiss* were reported in 2016-17 (California Department of Fish and Wildlife 2017b). NMFS expects that stranding of at least a small proportion of steelhead juveniles will continue with proposed action implementation and will adversely affect exposed individuals. The proposed action’s nocturnal ramping rates are designed to reduce stranding levels.

With regard to CCV steelhead spawning, a flow reduction from 8,000 cfs average flow during the spawning period to 3,250 cfs as prescribed by the end of September Shasta storage level would be expected to reduce spawning habitat by approximately 31 percent (U.S. Fish and Wildlife Service 2006). Likewise, flow reductions from 8,000 cfs to 4,000, 4,500 and 5,000 cfs would be expected to reduce spawning habitat by approximately 22, 17, and 12 percent, respectively. The species response to maintaining minimum winter flows of 3,250 cfs and increasing flood control releases in the upper Sacramento River could include spawning in temporarily inundated habitat during flood control releases. As flood control flows recede, any redds spawned in the temporarily inundated habitat are likely to be dewatered, which could lead to increased egg mortality.

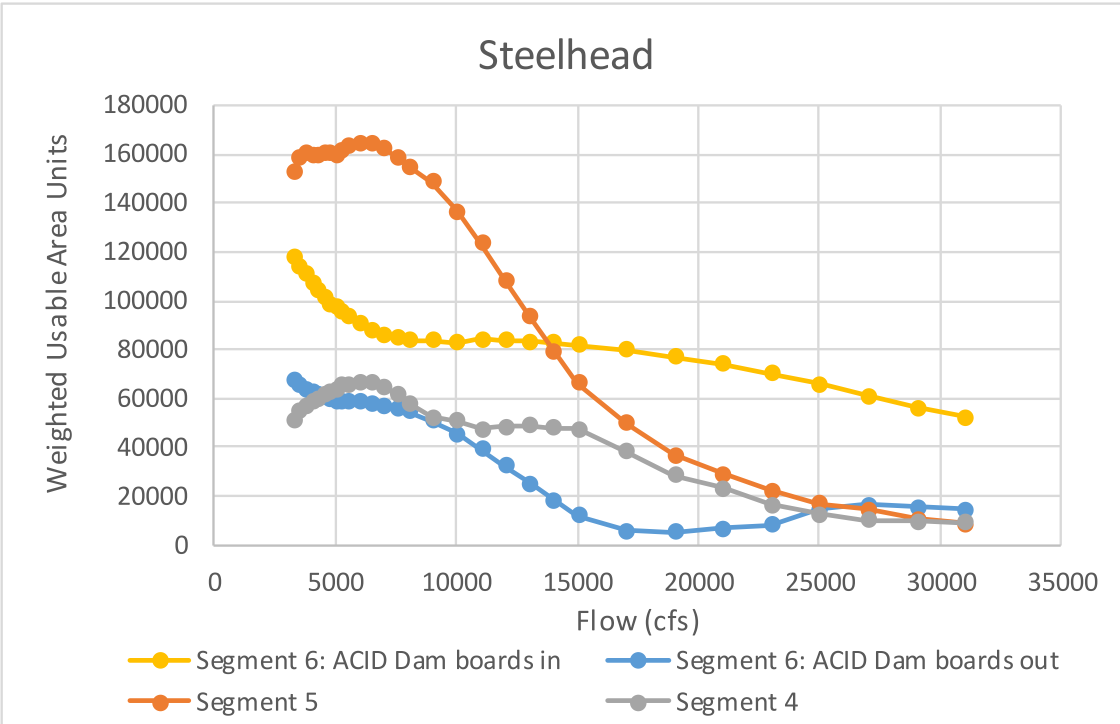


Figure 45. CCV steelhead spawning weighted usable area/Flow relationship (Keswick Dam to Battle Creek).

Overall, CCV steelhead weighted usable area analysis in the upper Sacramento River (Battle Creek to Keswick Dam) shows a decreasing spawning habitat weighted usable area value that corresponds to flows greater than 7,000 cfs for all reaches, and a combination of increasing and decreasing spawning habitat area in response to increasing flows between 3,250 and 7,000 cfs (Figure 45). For Segments 5 (Cow Creek to the Anderson-Cottonwood Irrigation District Dam) and 4 (Battle Creek to Cow Creek), the habitat-flow relationship shows a slight increase in value for flows between 3,250 cfs and 7,000 cfs, with only a slight peak at flows around 6,000 cfs. In the case of Segment 6 (Anderson-Cottonwood Irrigation District Dam to Keswick Dam), the weighted usable area analysis shows an optimum habitat carrying capacity at the lowest modeled flows, around 3,250 cfs.

NMFS considers that the managed changes water flow can reduce access to riparian habitat and instream cover in the immediate area of releases and floodplain and off channel habitats further downstream. However, we note that the lower flows proposed in the proposed action 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.

8.3.2.4 Green Sturgeon Exposure, Response, and Risk

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 to February period when Reclamation is managing the winter minimum flow component of the proposed action. However, adult green sturgeon migrate up river in March to early April, and spawning migrations often coincide with high Delta outflow in the spring. Therefore reductions in flows in February and March that affect Delta outflow 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 cues. Juvenile and adult green sturgeon have not been reported in the CDFW stranding surveys (California Department of Fish and Wildlife 2013b; California Department of Fish and Wildlife 2014b; California Department of Fish and Wildlife 2015b; California Department of Fish and Wildlife 2016b; California Department of Fish and Wildlife 2017b).

Adult green sturgeon also over-summer in spawning habitats and may be triggered to outmigrate with the first high flows, which sometimes occur in December. Though the extent of this over-summering is not defined, prolonged low winter flows could increase residency of adult green sturgeon in spawning habitat. While additional water coming into the system below Keswick Dam (i.e., tributary accretions) could reduce potential effects of prolonged minimum flows on the potential for increased period of residency, this component of operation may result in reduced survival probability of green sturgeon in the years in which it occurs.

8.3.3 Shasta Spring Operations

In the spring, the minimum winter reservoir releases are maintained until flows are needed to support Sacramento River instream demands and Delta outflow requirements, or releases are required for flood control operations. 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. 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.

NMFS used the modeling provided with the February 5, 2019 biological assessment to evaluate the effects of the proposed action, though we consider the uncertainties and discrepancies identified previously in this document.

8.3.3.1 February Forecast Process and Contractual Water Allocations

Reclamation targets February 20 of each year to make its initial forecast of deliverable water based on an estimate of precipitation and runoff within the Sacramento River basin. Although most irrigation does not begin until April or May, Reclamation provides this information to water users and agencies with an estimate of initial contractual water allocations so that the water users may begin their seasonal planning. Reclamation will use a similar conservative forecast for seasonal planning of reservoir releases for the proposed action (including developing initial and updated allocations) and temperature management planning. This includes monthly release forecasts and associated allocations based on a 90 percent exceedance inflow forecast through

September. Reclamation may deviate from relying on the 90 percent exceedance inflow forecast in order to develop a conservative outlook. Such instances include scenarios when a wetter hydrology produces a more conservative outlook, or the actual conditions are significantly drier than the existing forecast such that a more conservative forecast is appropriate. The proposed action also specifies that when the March 90 percent exceedance runoff forecast and temperature projection indicate a May 1 Shasta storage of less than 2.5 million acre-feet, Reclamation would initiate discussions with NMFS and the FWS regarding species intervention.

The proposed action for the February forecast includes the initial allocation of deliverable water (primarily delivered in May through October) that includes the north-of-Delta and south-of-Delta allocations (ROC on LTO biological assessment). Releases made from Shasta and Keswick dams to contribute to meeting these allocations have an effect on Reclamation's ability to maintain storage, which in turn may affect Reclamation's ability to provide adequate temperatures for spawning fish and incubating eggs during the summer. CalSimII modeling of both the current operating scenario and the proposed action show relatively similar delivery amounts for the north-of-Delta deliveries for the two scenarios (see Table 19 and Table 20).

Based on the proposed action modeling results, Reclamation does not show frequent instances of curtailing water deliveries prior to May 1 to achieve a higher storage on May 1. While shortages are included in the modeling to reflect allocations based on available water supply (or contract terms), the shortages primarily affect the deliveries May through October. Deliveries to CVP water service contractors subject to allocations is minimal prior to May 1st. Deliveries for north-of-Delta contracts commonly begin in April, the start of the spring operations period, and that deliveries are of small magnitude during this month. Deliveries begin increasing in May before reaching their highest demands in the summer months. Combined deliveries for both water service contracts and senior water right holders average more than 300 TAF in May, even in drier water year types (Table 21).

Reclamation uses a rule of thumb relationship between storage on May 1st and achievable seasonal temperatures along with modeling based on expected available coldwater pool to select a tier. An assumption of historical deliveries for May through October is incorporated into the rule of thumb relationship and a conservative estimate of deliveries will be incorporated in the temperature modeling. For this reason, Reclamation does not expect a change in tiers between May 1st and May 15th (the start of temperature management) due to expected water deliveries nor does Reclamation expect a change in tiers throughout the season due to forecasted deliveries. Because these demands are estimated when tiers are selected, the effects of these releases are assumed to be covered in the analysis of the proposed action and Reclamation would not anticipate a reduction in the performance of the proposed action due to months of high deliveries.

The combined modeled north-of-Delta deliveries in April, May, and June even in dry years average just under 800 thousand acre-feet (see rows corresponding to "D" under "AVG BY WYT" in Table 20). NMFS notes that the recent experience of the extreme drought in 2014 through 2016 and associated modeling scenarios demonstrates that the volume and stability of cold water pool throughout the temperature management season can be adversely affected by June and early July deliveries in addition to deliveries in April and May.

Table 19. Average north-of-Delta water service agricultural service contract deliveries by month and water-year type for both the current operating scenario and proposed action.

COS: North-of-Delta Deliveries to CVP Ag Service Contractors in TAF																
						<=====	Allocation/Contract Year				======	======			Full Year	
	======	======	======	======	====>									Oct-Apr	Mar-Feb	Allocation
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP		TOT	TOT	PCT
AVG:	4.7	0.2	0.0	0.0	0.1	1.2	18.5	36.9	47.6	56.9	45.4	20.2		24.6	230.3	65%
MIN:	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.5	0.0	0%
MAX:	14.9	1.9	0.0	0.0	4.4	17.2	44.3	63.8	81.5	95.8	77.5	37.5		65.5	357.1	100%
Avg by WYT	PRV	PRV	PRV													
W:	6.9	0.3	0.0	0.0	0.0	0.8	21.5	50.2	68.0	81.4	65.4	30.0		27.0	324.7	91%
AN:	5.2	0.1	0.0	0.0	0.0	0.5	23.7	50.0	65.3	77.3	61.1	27.5		28.1	308.4	86%
BN:	4.5	0.4	0.0	0.0	0.5	3.2	22.8	38.4	43.1	52.7	41.8	16.8		32.3	223.7	63%
D:	3.0	0.0	0.0	0.0	0.2	0.9	13.2	24.9	30.6	35.9	28.7	12.2		20.3	149.4	42%
C:	2.1	0.1	0.0	0.0	0.0	1.5	11.1	12.8	17.0	20.3	16.3	7.5		15.6	88.6	25%

PA: North-of-Delta Deliveries to CVP Ag Service Contractors in TAF																
						<=====	Allocation/Contract Year				======	======			Full Year	
	======	======	======	======	====>									Oct-Apr	Mar-Feb	Allocation
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP		TOT	TOT	PCT
AVG:	5.2	0.2	0.0	0.0	0.1	1.4	20.8	40.6	52.5	62.7	50.1	22.1		27.7	254.8	71%
MIN:	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.9	1.2	1.4	1.1	0.5		0.6	6.2	2%
MAX:	14.9	1.9	0.0	0.0	4.4	19.9	51.5	63.8	81.5	95.1	75.8	37.5		72.7	357.1	100%
Avg by WYT	PRV	PRV	PRV													
W:	7.2	0.3	0.0	0.0	0.0	0.8	22.6	51.0	70.0	83.7	67.1	30.8		28.5	333.8	93%
AN:	5.5	0.1	0.0	0.0	0.0	0.6	25.5	51.2	69.7	82.2	65.1	29.2		30.2	328.3	92%
BN:	5.7	0.5	0.0	0.0	0.5	4.3	28.8	50.0	54.9	67.2	53.3	21.1		40.0	285.8	80%
D:	3.7	0.0	0.0	0.0	0.2	1.1	16.0	30.4	37.4	44.0	35.2	15.0		24.2	182.8	51%
C:	2.4	0.1	0.0	0.0	0.0	1.7	12.7	14.9	19.3	23.3	18.8	8.1		18.1	101.4	28%

Table 20. Average north-of-Delta settlement contract deliveries by month and water-year type for both the current operating scenario and proposed action.

COS: North-of-Delta Deliveries to CVP Settlement Contractors in TAF																
						<=====	Allocation/Contract Year				======	======			Full Year	Fraction of
	======	======	======	======	====>									Oct-Apr	Mar-Feb	Hist Max
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP		TOT	TOT	PCT
AVG:	75.7	24.0	7.3	1.4	0.6	7.1	81.0	305.9	352.0	381.6	294.3	77.1		197.1	1608.7	94%
MIN:	6.2	3.5	0.0	0.0	0.0	0.0	29.1	145.5	287.4	322.0	241.0	23.5		60.2	1388.2	81%
MAX:	95.9	43.7	20.1	9.0	13.6	58.6	123.7	358.8	398.9	407.7	331.1	89.7		302.1	1719.1	100%
Avg by WY	PRV	PRV	PRV													
W:	78.5	24.1	8.8	0.8	0.0	3.1	70.0	301.7	335.8	392.3	318.6	81.3		170.6	1617.0	94%
AN:	75.4	23.7	6.2	0.5	0.0	1.6	78.0	300.2	350.0	388.8	298.8	79.0		179.8	1607.9	94%
BN:	75.3	26.6	7.4	2.9	1.9	13.3	90.3	314.4	364.6	390.3	293.4	69.8		219.5	1646.4	96%
D:	76.9	20.8	7.6	1.7	0.9	7.3	83.2	320.3	378.9	384.4	282.8	76.8		208.6	1640.5	95%
C:	68.3	27.3	4.5	1.8	0.9	15.3	95.5	289.8	332.8	338.4	256.6	72.9		233.4	1504.2	88%
PA: North-of-Delta Deliveries to CVP Settlement Contractors in TAF																
						<=====	Allocation/Contract Year				======	======			Full Year	Fraction of
	======	======	======	======	====>									Oct-Apr	Mar-Feb	Hist Max
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP		TOT	TOT	PCT
AVG:	60	30	7	1	1	7	81	306	352	382	294	77		187	1599	93%
MIN:	6	12	0	0	0	0	29	146	287	322	238	24		66	1372	80%
MAX:	86	49	20	9	14	59	124	359	399	408	335	90		295	1715	100%
Avg by WY	PRV	PRV	PRV													
W:	62	30	9	1	0	3	70	302	336	392	319	81		159	1607	94%
AN:	60	29	6	0	0	2	78	300	350	389	299	79		169	1597	93%
BN:	61	32	7	3	2	13	90	314	365	390	293	70		208	1637	95%
D:	59	27	8	2	1	7	83	320	379	384	283	77		201	1629	95%
C:	59	33	5	2	1	15	96	290	333	338	255	71		227	1498	87%

Reclamation has stated that springtime operations of Shasta and Keswick dams are intended to support instream demands on the mainstem Sacramento River and Delta outflow requirements. Sacramento River Settlement Contracts obligate Reclamation to release sufficient water from Shasta and Keswick reservoirs to meet the full quantities of water and allocation between base supply and Project water under those Contracts; these releases under most conditions reduce late spring and early summer storage. During Shasta Critical Years, as defined under the Sacramento River Settlement Contracts, those contract quantities are reduced to 75 percent.

The combined modeled (agricultural service and the settlement contractors) north-of-Delta deliveries for the proposed action in April, May, and June in dry years can average over 800 thousand acre-feet (sum of rows corresponding to “D” under “AVG BY WYT” in Table 19 plus Table 20) and NMFS considers that the proposed action does not include any specific modifications to the timing of these deliveries to further assist temperature management.

CalSimII is a representation of the historical demand and delivery up to the full contracted amounts from the past 15 years. The CalSimII results are the best available information for evaluating effects of spring operations for the proposed action and current operating scenario. NMFS has considered historical operations regarding these contracts but does not have adequate information to quantitatively include deviations from the modeled operations into the assessment of effects. NMFS therefore assumes that the CalSimII model results of flows below Keswick Dam in February through May provide a reasonable approximation of the effects of operational decisions, including fulfilling underlying contractual obligations, that are being made regarding spring operations for both the current operating scenario and the proposed action.

Though it is limited in that it cannot capture all conditions or constraints on operations, the CalSimII modeling shows that in the spring, the proposed action would increase north-of-Delta agricultural service contract deliveries (Table 21), decrease Delta outflow and increase total exports (Table 22) compared to the current operating scenario (see Appendix B).

Tables 21 and 22 show modeled volumes of deliveries to meet contracts throughout the year. In the drier months (typically the summer and spring of drier years), much of these deliveries are met through storage withdrawls from Shasta Reservoir which can be considered when assessing impacts of deliveries on summertime temperature management actions. This modeling shows that from February through May, the proposed action is very similar to current operating scenario with proposed action flows below Keswick Dam a few hundred cfs higher than the current operating scenario. Though it is limited in that it cannot capture all conditions or constraints on operations, the CalSimII modeling shows that in the spring, the proposed action would increase north-of-Delta agricultural service contract deliveries, decrease Delta outflow, and increase total exports compared to the current operating scenario.

Table 21. CalSimII modeling results of monthy outflows below Keswick, proposed action minus current operating scenario.

	Monthly Outflow (cubic feet per second)											
Statistic	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Probability of Exceedance												
10%	-2,320	2,128	2,932	1,887	1,439	4,592	-5,178	-5,280	536	698	91	-14,058
20%	-4,996	-6,009	2,669	2,638	957	437	-4,528	-3,315	727	532	-12	-15,148
30%	-5,223	-7,836	4,505	-245	-506	-1,149	-3,824	-3,400	641	66	0	-11,288
40%	-2,969	-7,267	986	53	3,753	-1,206	-3,976	-4,003	741	0	0	-6,941
50%	-1,374	-5,199	755	1,412	217	-558	-4,361	-2,698	516	0	0	142
60%	0	-1,811	1,097	-293	-499	1,102	-2,854	-1,487	238	0	0	0
70%	0	0	560	201	-815	-902	-2,482	-719	163	0	-173	0
80%	0	0	406	-119	-1,150	-232	-1,492	-263	1,056	0	-211	0
90%	0	0	0	-146	-502	-1,493	-587	-234	326	0	0	0
Long Term Full Simulation Period [a]												
	-1,574	-2,522	2,133	709	466	450	-2,949	-2,367	479	-147	-44	-5,300
Water Year Types [b]												
Wet (32%)	-3,584	-5,943	4,477	1,771	1,256	1,009	-4,446	-4,039	751	-266	1	-13,297
Above Normal (16%)	-1,982	-3,628	3,075	673	2,046	2,175	-4,167	-3,157	840	-506	-10	-7,069
Below Normal (13%)	-312	-467	516	739	2,357	508	-2,597	-1,810	343	26	55	167
Dry (24%)	-335	30	644	-93	-1392	-680	-1,777	-1,120	264	56	-181	57
Critical (15%)	0	-48	0	-241	-1596	-799	-663	-476	-16	0	-40	0

[a] Based on the 82-year simulation period; [b] As defined by the Sacramento Valley 40-30-30 index water year hydrologic classification (SWRCB D-1641); Results displayed with calendar year-year type sorting; All scenarios are simulated at early long-term Q5 with 2025 climate changes and 15 centimeter sea level rise; Draft results meant for qualitative analysis and subject to revision

Source:ROC on LTO biological assessment, Appendix D

Table 22. CalSimII modeling results of total exports, proposed action minus current operating scenario.

	Monthly Deliveries (cubic feet per second)											
Statistic	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Probability of Exceedance												
10%	3,461	32	-35	-126	-140	-449	4,529	4,571	-521	11	0	0
20%	3,638	1,946	-758	46	-78	-565	4,815	4,974	-90	0	0	0
30%	3,215	2,081	-1,670	533	15	-359	4,497	4,235	-364	144	-20	0
40%	2,330	1,575	-773	312	213	53	4,438	4,086	-324	-93	0	130
50%	1,299	1,172	-700	398	402	211	3,838	3,693	747	-506	543	1,019
60%	361	491	-696	308	373	318	3,062	2,836	1,296	-415	926	747
70%	182	-170	-700	380	729	1,145	1,707	2,211	1,401	-783	120	-136
80%	27	-231	-47	680	1,703	1,225	1,304	1,734	2,304	-1,462	151	-173
90%	-174	-21	-118	1,381	2,951	2,198	954	877	1,441	-665	32	-105
Long Term Full Simulation Period [a]												
	1,397	726	-548	393	742	404	2,971	2,977	660	-272	149	215
Water Year Types [b]												
Wet (32%)	2,688	2,341	-474	312	-31	-502	4,476	4,244	-232	-24	-79	304
Above Normal (16%)	2,645	258	-1,579	899	149	-225	4,433	3,966	-152	400	-58	144
Below Normal (13%)	99	52	-615	737	1,071	548	2,737	2,865	1,656	226	1,099	518
Dry (24%)	445	-281	-157	148	1,371	1,234	1,549	2,069	1,544	-1,161	252	69
Critical (15%)	24	34	-183	110	1,709	1,535	713	781	1,089	-512	-178	64

[a] Based on the 82-year simulation period; b As defined by the Sacramento Valley 40-30-30 index water year hydrologic classification (SWRCB D-1641); Results displayed with calendar year-year type sorting; All scenarios are simulated at early long-term Q5 with 2025 climate changes and 15 centimeter sea level rise; Draft results meant for qualitative analysis and subject to revision

Source:ROC on LTO biological assessment, Appendix D

The proposed action includes the 2018 revision to the *Coordinated Operations Agreement*, which altered the sharing commitments between Reclamation and DWR from the CVP reservoirs, including Shasta, in dry and critical years as compared to historical operations. In these water year types, the 2018 *Coordinated Operations Agreement* revision helps conserve Shasta cold water pool conditions to the maximum extent practicable. This action is consistent with the RPA Actions I.2.3.B and I.2.2.C of the NMFS 2009 Opinion, which directed Reclamation to consider a number of actions in drought (or low Shasta storage conditions) to help conserve and/or build Shasta storage for better cold water pool management, including directing Reclamation and DWR to make releases first from Folsom Reservoir and then from Oroville Reservoir to meet Delta outflow or other legal requirements before making releases from Shasta Reservoir. Reclamation and DWR implemented this action once during the extreme drought in 2014-2016. Reclamation has committed to coordinating with DWR to develop a voluntary toolkit to be exercised at the discretion of Reclamation, DWR, other agencies, participating water users, and/or others for the operation of Shasta Reservoir during critical hydrologic year types. Reclamation will meet and confer with FWS, NMFS, DWR, CDFW, and Sacramento River Settlement Contractors on voluntary measures to be considered. In addition, the Sacramento River Settlement Contractors commit to meet and confer with Reclamation and NMFS to determine if there is any role for the Sacramento River Settlement Contractors in connection with Reclamation's operational decision-making for Shasta Reservoir in Tier 3 and Tier 4 years (See Section 2.5.2.6). Implementation of a drought contingency plan will be based on the real time conditions observed and the interaction with other State and Federal requirements.

8.3.3.2 Spring Base Flows

Reclamation is proposing to maintain the minimum winter releases (described in Section 2.5.2.3.1.1 Winter Minimum Flows) into the spring and until "flows are needed to support instream demands on the mainstem Sacramento River and Delta Outflow requirements" (U.S. Bureau of Reclamation 2019c). Modeling confirms that for both the proposed action and the current operating scenario, early spring (February - April) flows are maintained at minimum levels to build storage. The CalSimII modeling indicates that Sacramento River flows at Keswick Dam are increased in the late spring (May). Increased Keswick release is primarily done to meet agricultural demands and south-of-Delta exports.

Juvenile CV spring-run Chinook salmon migration out of Mill and Deer creeks begins in mid-to-late April, 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 to 2010). And while CalSimII modeling of the proposed action and current operating scenario shows Keswick releases increasing in May for the proposed action, this increase is made in part to satisfy agricultural deliveries which then reduce flows downstream of the point of diversion (i.e., at Wilkins Slough). These diminishing flows are also described in the modeling for both the proposed action and the current operating scenario where average flows at Wilkins Slough in May are approximately 6,500 to 7,000 cfs, which is 1,200 to 1,300 cfs lower than flows below Keswick Dam. 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 November to May (University of Washington Columbia Basin Research 2019).

These fish are subject to a managed spring base flow hydrograph. Reclamation has proposed a managed spring pulse flow to alleviate effects of these low flow habitat conditions. A similar effect of steady flows could manifest for adult sDPS green sturgeon that migrate up river in March to early April coincident with high Delta outflow. We consider that the managed changes in the hydrograph can reduce the strength of the seasonal spawning cues for this species, and the proposed managed spring pulse flow could alleviate the effects of the managed low flows.

The proposed action states that spring releases (besides flood control operations) are expected to be steady until flows are needed to support instream demands on the mainstem Sacramento River and Delta outflow requirements. In wetter springtime conditions, downstream demands are generally met through unstored accretions to the system, and Reclamation expects to be able to reduce Keswick flows in the late winter/early spring below those proposed for the fall-winter period in order to build and/or retain additional storage.

Salmon and sturgeon have access to floodplain habitat 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 includes notching the Fremont Weir, which will provide access to floodplain habitat for juvenile salmon over a longer period (California Department of Water Resources and U.S. Bureau of Reclamation 2012).

The low spring base flows expected at Keswick under the proposed action can affect travel time and outmigration contribute to the loss of juveniles floodplain habitat, especially when tributary accretions to the system are limited from March through May making the Keswick release a high proportion of the total flow. A recent assessment of mark-recapture survival models in the Sacramento mainstem show 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; Michel et al. 2015; Zeug et al. 2014). 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 to the the year with higher water flow (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 floodplain access and therefore on downstream migration and survival particularly when tributary accretion flows are low.

8.3.3.3 Spring Pulse Flows

Reclamation is proposing to implement a spring pulse flow under certain hydrologic conditions to improve the survival of out-migrating juvenile salmonids, specifically CV spring-run Chinook salmon. In coordination with the NMFS-SWFSC, Reclamation, and California Department of Fish and Wildlife, NMFS has recently developed a CV spring-run Chinook salmon pulse flow experiment to assess the effectiveness of a spring pulse flow that is implemented through coordinated water operations (i.e., either increased reservoir releases or decreased river diversions). Existing data from previous telemetry studies (Michel et al. 2015; Notch 2017) show that increases in survival in the upper and lower Sacramento River have been strongly correlated with increases in flow resulting from tributary accretions. These increases in flow during past telemetry studies were triggered by storm events resulting in increased outflow from Sacramento River tributaries. CV spring-run Chinook salmon and fall-run Chinook salmon tagging data from

2012-2017 show a significant increase in smolt survival when Sacramento River flow at Wilkins Slough is above 9,100 cfs during the outmigration period (Cordoleani 2019). Although it remains to be seen whether a spring pulse flow mediated by water operations would have the same benefit as a natural rain-driven spring pulse, Reclamation is proposing a spring pulse flow as part of water operations with consideration of certain hydrologic and operational constraints.

Reclamation would evaluate the projected May 1 Shasta Reservoir storage at the time of the February forecast to determine whether to make a spring pulse of up to 150 thousand acre-feet in coordination with the Upper Sacramento scheduling team. To support their ability to improve temperature conditions, Reclamation would not make a spring pulse release if the release would cause operations to drop into a warmer Tier of the Shasta summer cold water pool management tiers (e.g., the additional flow releases would decrease cold water pool such that summer Shasta temperature management operations move to Tier 3 from an initial operation of Tier 2) or interfere with the ability to meet other anticipated demands on the reservoir.

For the operations described in the proposed action, Reclamation, in coordination with the Upper Sacramento scheduling team, could implement up to 150 thousand acre-feet of spring pulse flows for juvenile salmonid outmigration if Shasta Reservoir total storage on May 1 is projected to be sufficient for cold water pool management (i.e., greater than 4 million acre-feet). Reclamation would evaluate the projected May 1 Shasta Reservoir storage at the time of the February forecast to determine whether a spring pulse would be allowed in March, and would evaluate the projected May 1 Shasta Reservoir storage at the time of the March forecast to determine whether a spring pulse would be allowed in April. Though not explicitly specified in the biological assessment, NMFS assumes that this projection will be based on the 90 percent exceedance forecast in March and April. According to the proposed action description, this projection will be based on the 90 percent exceedance forecast in March and April.

Reclamation did not analyze the action in the original modeling for the January 31 biological assessment but conducted a post-process analysis on October 3, 2019 to better understand the timing, impacts, and benefits of the action. This analysis quantified the volume of water in Shasta that could be used to create a spring pulse flow while keeping storage above 4.1 MAF on May 1, and keeping storage above 4.0 TAF on June 1. Also, a conservative perspective was built in to the analysis by enabling these additional releases only in Wet and Above Normal years. The pulse flows could be released in other years types when sufficient coldwater pool is available, but Reclamation applied this assumption to reflect the anticipated use of early-season conservative forecasts to make implementation decisions.

Based on this analysis, a pulse flow of 150 thousand acre feet can be released in 53 percent of years, with a smaller pulse available in additional four percent of years. Under proposed action modeling, the full 150 thousand acre feet is anticipated to be met through:

- Flood control releases 44 percent of the time
- Combination of storage and flood control three percent of the time
- Release from only storage six percent of the time
- An additional Spring Pulse Flow of less than 150 thousand acre feet released from storage is projected to be available in four percent of years.
- In the remaining 43 percent of years, the Reclamation’s analysis did not induce any pulse low due to potential impacts to cold water pool or other operations, although in many of

these years, particularly Below Normal years, may have sufficient resources to support storage releases for a pulse flow.

Implementing a spring pulse to benefit out-migrating juveniles can affect temperature-dependent egg mortality in the summer by reducing the volume of water available for use later in the season. Even though the pulse may occur in May, the impacts to temperature management might not manifest until the end of the season when the volume of cold water is likely at its lowest. Recent analysis of the effects of a 10,000 cfs spring pulse at Wilkins Slough focused on estimating the spring pulse impact on winter-run Chinook salmon temperature-dependent egg mortality and the water cost associated with conducting a spring pulse originating from Shasta Reservoir (Daniels et al. 2019). The ensemble-based approach simulated the spring pulse over a 16-year period (2000-2015), assuming this represented a reasonable range of meteorology, hydrology, and operations for the near future. For each day from May 1 to May 15 during the pulse time window for a given simulation year, the analysis estimated the volume of water required for Wilkins Slough discharge to equal 10,000 cfs for three continuous days, followed by a 15 percent daily ramping down rate to base conditions. This volume of water represented the additional amount of water required from Shasta Reservoir for the pulse to occur. Since the calculation was run for each day in the pulse time window, it was possible to assess the sensitivity of the water cost associated with the day the pulse started and estimated a range of potential water cost values.

Using this information, a “pulse” and a “no pulse” scenario were evaluated using the temperature-dependent egg mortality model for each simulation year. The no pulse model used observed conditions for all model inputs and was considered the base model. The pulse model used observed conditions, except for discharge from Shasta and Keswick reservoirs, and in the Sacramento River during the time period when a pulse was considered. During that time period the time series was perturbed to simulate a pulse.

This analysis found that the simulated effect of the spring pulse varied by water year type, with the largest impact occurring during dry and critical years. Water costs associated with a spring pulse varied from zero thousand acre-feet during wet years to as much as 50 thousand acre-feet during drier hydrological years. In most years, the water cost was less than 30 thousand acre-feet (Figure 46). The releases of water in the spring period had effects on temperature management later in the summer season; the simulated increase in Shasta discharge temperature associated with the spring pulse was often less than 0.5°F, but was as much as 1°F. The effects of the simulated May pulse operation on temperature management later in the year results in a simulated winter-run Chinook salmon temperature-dependent egg mortality increase that was often less than two percent, mostly in below normal, above normal, and wet water year types (Figure 47). Dry and critically dry years had an average increase of more than 4 percent in winter-run Chinook salmon egg mortality, but the range was as high as 8 percent when considering the 75th percentile estimate. This analysis considered survival over the entire time period from the pulse to the end of December for a given year. These results support Reclamation’s proposal to implement this action in wetter water years, and when Shasta Reservoir total storage on May 1 is projected to be sufficient for cold water pool management.

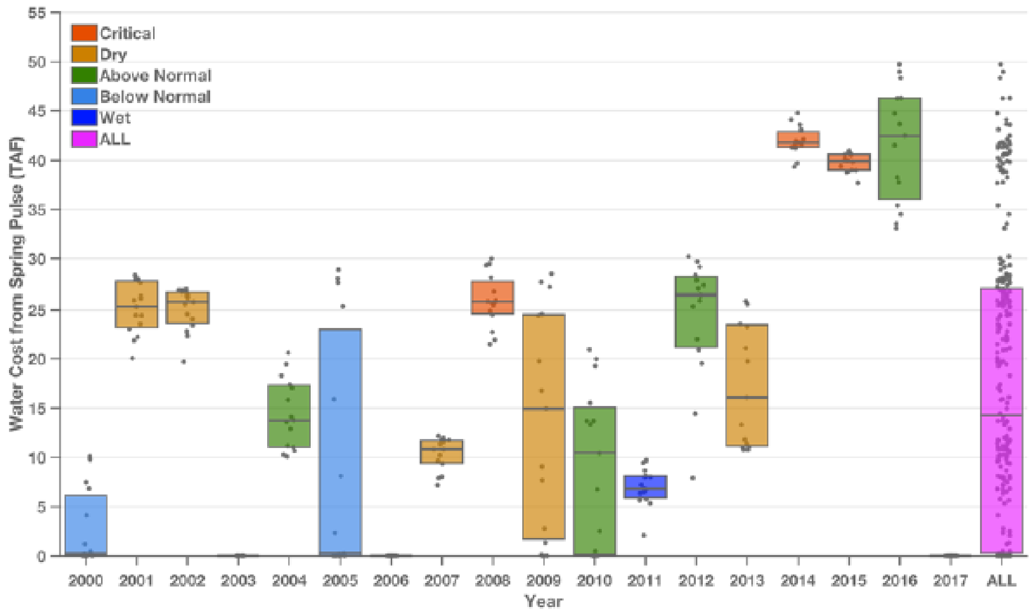


Figure 46. Water costs associated with spring pulse simulation. Box encompasses 25th and 75th percentile of water cost associated with sensitivity to pulse start date.

Source: Preliminary data figures from (Daniels et al. 2019)

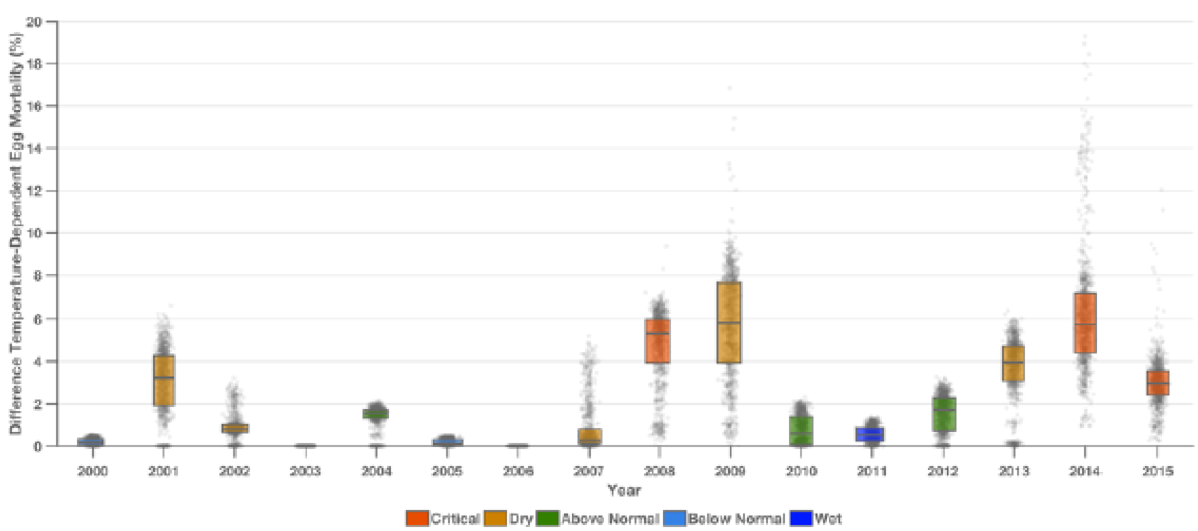


Figure 47. Distribution of temperature-dependent egg mortality increase associated with simulated pulse. Boxes encompass 25th and 75th percentile associated parameter uncertainty from 50 ensembles.

Source: Preliminary data figures from (Daniels et al. 2019)

As proposed, a spring pulse flow occurring between March 1 and May 15 is expected to result in increased survival of juvenile salmonids by mimicking the natural hydrologic cues that trigger salmonid outmigration (Kjelson et al. 1981). Spring pulse flows would likely result in increased turbidity, which would provide a level of cover from predators for outmigrating juveniles that may not occur with a managed spring pulse.

8.3.3.3.1 Winter-Run Chinook Salmon Exposure, Response, and Risk

The proposed spring pulse flows would occur sometime from March 1 to May 15 when the majority of winter-run Chinook salmon juveniles either have entered the Delta or have completed their migration to the ocean. 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 winter-run Chinook salmon juveniles have entered the Delta (Figure 48) and migrated downstream past the influence of a spring pulse flow. For winter-run Chinook salmon juveniles, exposure to the spring pulse is 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.

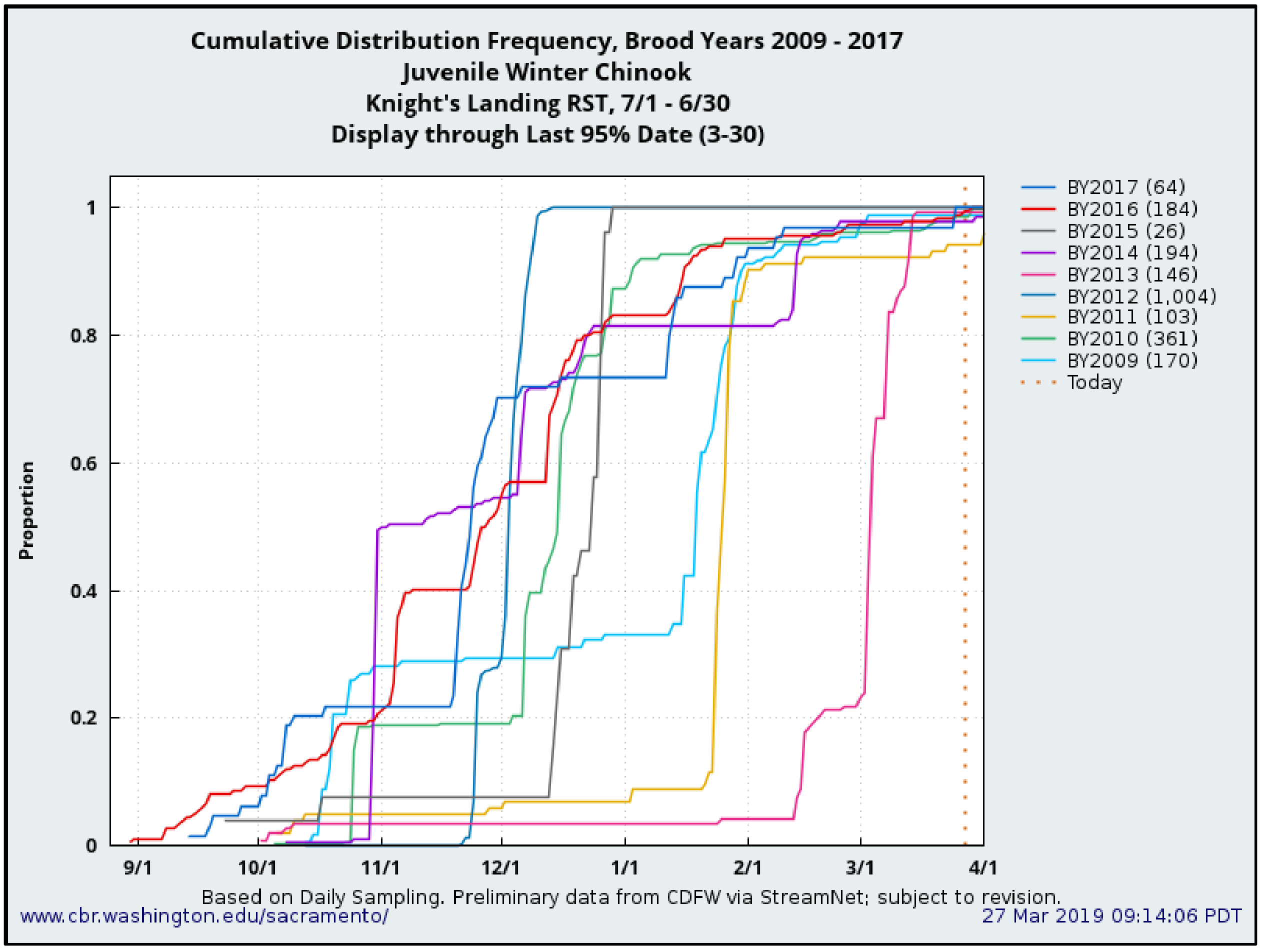


Figure 48. Knights Landing rotary screw trap Juvenile Winter-run Chinook passage data from 2009 to 2017.

Spring pulses are also expected to benefit adult winter-run Chinook salmon migrating up the Sacramento River later in the spring. The spring pulses would provide improved *Water flow* that in turn provide cooler temperatures (improved *Water Temperature*), and allow for better passage conditions.

However, a springtime pulse could have an effect on the ability to manage cold water throughout the summer temperature management season (Daniels et al. 2019). This could increase the risk of temperature-dependent mortality to winter-run Chinook salmon eggs 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. The pulse is assumed to occur in fewer than 75 percent of years, and in mostly wetter years when May 1 storage is greater than 4 million acre-feet. The analysis showed that risk to winter-run Chinook salmon in these years was often a less than two percent increase in temperature-dependent mortality, though the increase was greater in drier water year types, sometimes increasing up to over seven percent

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8.3.3.3.2 CV Spring-Run Chinook Salmon Exposure, Response, and Risk

The proposed spring pulse flow 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 (May 15). Specifically, based on the last 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.

Species response to a spring pulse would be decreased travel time for juveniles, affecting survival (improved water flow), and a temporary increase in riparian habitat accessibility. Because the spring pulse period also overlaps with adult CV spring-run Chinook salmon upstream migration in March – September (Yoshiyama et al. 1998), the spring pulses are also expected to have the beneficial effects of reducing water temperatures (improved Water Temperature) and improving passage (reduced Passage Impediments/Barriers). A spring pulse flow could have a mitigating effect on the stressors related to water operations by improving water flow.

8.3.3.3.3 CCV Steelhead Exposure, Response, and Risk

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. 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 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 May 1 Shasta storage of 4 million acre-feet 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 decreased travel time for juveniles improving survival (improved water flow) and a temporary increase in riparian habitat accessibility. The spring pulse period does not overlap significantly with adult CCV steelhead migration, which occurs predominately July through December (McEwan 2001).

8.3.3.3.4 sDPS Green Sturgeon Exposure, Response, and Risk

The timing of sDPS green sturgeon adult migration and spawning is such that a large proportion of green sturgeon are expected to be in the mainstem Sacramento River in March through July (Poytress et al. 2015). The proposed spring pulse flow would occur from March 1 to May 15 if implemented.

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/barriers to migration and increasing the frequency of high flow events, which are otherwise limited (altered flow).

8.3.3.4 Spring Management of Spawning Locations

Reclamation has proposed continued coordination with NMFS to establish research to determine if maintaining colder water earlier in the year induces earlier spawning, or if warmer April/May Sacramento River temperatures induces later spawning. NMFS supports research related to understanding how the timing of winter-run Chinook spawning is affected by temperature and further consideration of results related to spring temperature management. This consideration is based on emerging research that indicates the spawning 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). Specifically, there is evidence that higher April water temperatures correspond to increased and delayed spawning in July and August (Hendrix et al. 2017) (Figure 49). Although there is little description of this action component or how it may affect the species, this action may lead to improved reproductive success.

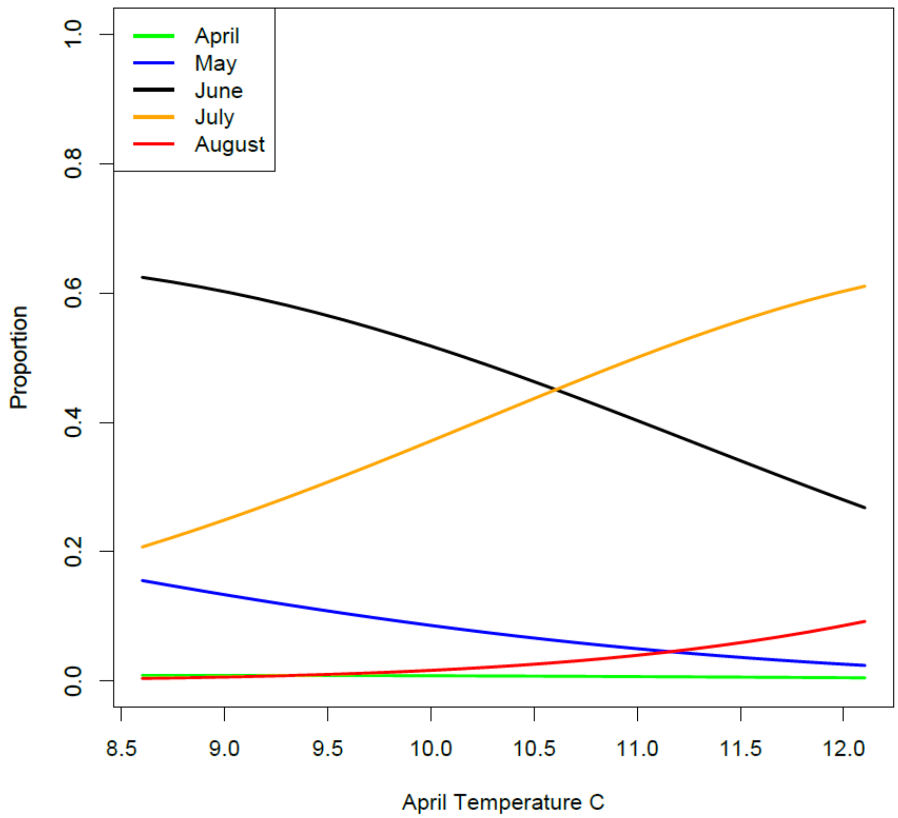


Figure 49. Predictions of the proportion of winter-run Chinook salmon spawning from the multinomial regression model using April temperatures at Keswick Dam as a predictor value.

Source: (Hendrix et al. 2017)

In order to provide enough certainty that the proposed action component would be implemented, and to assess its effects, this component of the proposed action will need to be developed further. This information should include an experimental design to know what operation is required for the evaluation.

8.3.4 Shasta Summer Operations

During the summer, Reclamation's operational considerations are primarily flows required for Delta outflows, instream demands, and temperature control downstream of Keswick Dam. These underlying operational considerations remain the same for both the current operating scenario and the proposed action.

The proposed action includes the Delta Smelt Summer-Fall Habitat action component, which proposes to use structured decision-making to annually implement habitat actions that support Delta Smelt recruitment in the summer and fall (June through October). This action is intended to maintain low salinity habitat in the estuary when water temperatures are suitable, manage the low salinity zone to overlap with turbid water and available food supplies; and establish a contiguous low salinity habitat through the estuary. The proposed action identifies that Reclamation intends to provide any needed Delta outflow augmentation in the fall primarily through export reductions, but that storage releases from upstream reservoirs may be used to initiate the action by pushing the salinity out further in August and early September. The need for this initial action will depend on the particular hydrologic, tidal, storage, and demand conditions at the time. To the extent that the effects of this action are within the operations characterized by the Shasta summer operations, take is authorized for the Delta Smelt Summer-Fall Habitat action component in this Opinion.

8.3.4.1 Summer Cold Water Pool Management

Reclamation proposes to operate the temperature control device at Shasta Dam to continue providing temperature management in accordance with CVPIA 3406(b)(6) while minimizing impacts on power generation. Cold water pool is defined as the volume of water in Shasta Reservoir that is cooler than 52°F. Reclamation would determine this volume based on monthly (or more frequent) reservoir temperature profiles.

Reclamation proposes to address Summer Cold Water Pool Management using a four-tier strategy that allows for strategically selected temperature objectives based on projected total storage and cold water pool, meteorology, Delta conditions, and species needs. The tiered strategy recognizes that cold water may be a limited resource that Reclamation should manage to achieve desired water temperatures for fisheries objectives. Actual operations will depend upon the available cold water and modeling. Once the initial tier is selected on May 1, Reclamation will not cause Shasta cold water pool management to shift into a warmer tier during real-time implementation of the Shasta Cold Water Management Plan except in the event of responding to emergency and/or unforeseen conditions. Furthermore Reclamation will use various operational flexibilities and/or contingency actions after May 1, potentially including adjusting initial allocations in accordance with all contract requirements, to stay within a Tier, unless the change is caused by events outside Reclamation's control or beyond what was planned for in the temperature management plan. Figure 50 (Figure 4-4 from the ROC on LTO biological assessment) provides a decision tree explaining the decision points for Shasta Reservoir temperature management.

The initial determination of operational tier for an upcoming summer is based on the available storage on May 1 and temperature modeling of conditions at that time. Figure 50 was provided by Reclamation to describe the assumed relationship between total Shasta storage on May 1, corresponding cold water (i.e., less than 52°F) pool availability, and an estimated daily average temperature at Clear Creek gauging station that could be met during the summer temperature management period of May 15 to October 31. The proposed action indicates that Reclamation has based the development of the cold water pool management Tiers on recent history of Sacramento River temperature management below Keswick Dam.

Using the information reflected in Figure 50, Reclamation has identified the following definitions of operational Tiers:

- Tier 1: May 1 more than 2.8 million acre-feet of cold water pool in Shasta Reservoir or modeling suggests that a daily average temperature of 53.5°F at Clear Creek gauging station can be maintained from May 15 to October 31;
- Tier 2: May 1 cold water pool volume between 2.3 and 2.8 MAF or modeling suggests that the 53.5°F at Clear Creek gauging station cannot be maintained from May 15 to October 31 but can be maintained for shorter periods with other periods at or below 56°F;
- Tier 3: May 1 cold water pool less than 2.3 MAF or modeling suggests that 53.5°F at Clear Creek gauging station cannot be maintained from May 15 to October 31 but a temperature between 53.5°F and 56°F can be maintained for shorter periods with other periods at or below 56°F; and
- Tier 4: May 1 total storage less than 2.5 MAF or or modeling suggests that 56°F at Clear Creek gauging station cannot be maintained from May 15 to October 31.

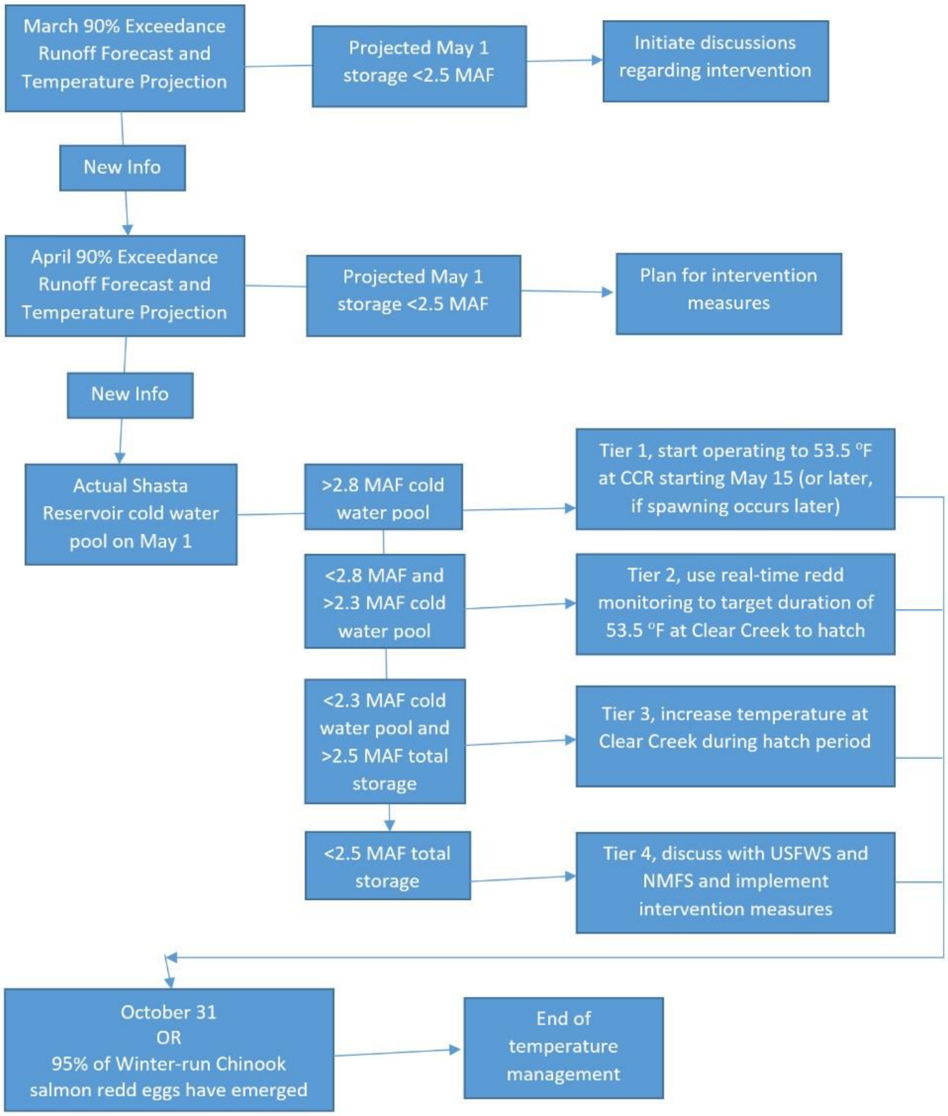


Figure 50. Decision tree for Shasta Reservoir Cold Water Pool Management.

Source: ROC on LTO biological assessment Figure 4-4

In using the biological assessment modeling to support the analysis of effects to the species, NMFS notes that the certainty of operating in any Tier is dependent on the accuracy of the characterization of the operations in the proposed action modeling and the ability of actual operations to commit to the operations as characterized in the modeling. Based on the 82-year historical hydrologic sample set used in the CalSimII modeling of the proposed action, Shasta storage conditions over the long-term would designate Tier 1 operations in 68 percent of years, Tier 2 operations in 17 percent of years, Tier 3 operations in 7 percent of years, and Tier 4 operations in 7 percent of years. To better address the uncertainty associated with the frequency of operating in each Tier, NMFS considered the historical record of Shasta storage. Historically, May 1 Shasta storage is 4.1 million acre-feet less frequently than the CalSimII modeling predicts for the proposed action. Table 23 shows the proportion of years May 1 Shasta storage is equal to or greater than 4.1 million acre-feet over different periods of Shasta Dam's history. This is not surprising since the proposed action includes specific changes from historical operations to build additional storage and coldwater pool; however NMFS considers this historical performance in its analysis.

Table 23. Proportion of years in which Shasta Reservoir total storage is greater than or equal to 4.1 million acre feet (MAF) on May 1.

Years	Percent with storage greater than 4.1 MAF	Rationale for period considered
1953-2018	57%	Limit of readily available data
1980-2018	49%	New Melones and D-1485 to present
1996-2018	52%	D-1641 to present
2010-2018	62%	NMFS 2009 Opinion to present

As proposed in the proposed action, implementation of temperature management would start after May 15, or when the monitoring working group determines, based on real-time information, that winter-run Chinook salmon have spawned, whichever is later. Since the Tier determination is intended to be based on the May 1 storage value and modeling of anticipated conditions, anticipated operations between May 1 and May 15 will be incorporated into the temperature analysis and tier selection. The operations dring this period were accounted for in the "rule of thumb" analysis presented by Reclamation.

Additionally, there is a lag time in the detection of the first 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 to 10 days, or more, later than the actual onset of spawning. The onset of spawning is especially important in the implementation of Tiers 2 and 3, when Reclamation proposes to center temperature management on the projected time period when the winter-run Chinook salmon eggs have the highest dissolved oxygen requirement (37 to 67 days post fertilization). Finally, Reclamation's proposed onset of temperature management (i.e., based on real-time monitoring of redd timing) indicates that spawning at the Livingston Stone National Fish Hatchery is not considered. There have been years where spawning at Livingston Stone National Fish Hatchery occurred prior to the first detection of winter-run Chinook salmon spawning in the Sacramento River. The challenge of managing this information and response, given limitations of monitoring, is expected to be addressed in the development of temperature management plans and through the Livingston Stone National Fish Hatchery operational planning, both of which are expected to be coordinated with NMFS.

As proposed in the proposed action, temperature management would conclude October 31, or when the monitoring working group determines based on real-time monitoring that 95 percent of winter-run Chinook salmon alevin have emerged, whichever is earlier. NMFS notes that existing monitoring methods likely will not be able to indicate the date of 95 percent redd emergence. 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 95 percent of the redds were constructed, which would be required to know date of emergence.

The thresholds used in this Opinion for temperature effects on the life-stages of salmonids are described in the EPA Region 10 Guidance for Pacific Northwest State and Tribal Temperature Water Quality Standards (U.S. Environmental Protection Agency 2003). The guidance was jointly developed by EPA, FWS, NMFS, States, and Tribes in the Pacific Northwest. They examined the most recent science at that time on the temperature effects on salmonid physiology and behavior, the combined effects of temperature and other stressors on threatened fish stocks, the pattern of temperature fluctuations in the natural environment, and other relevant issues. The project culminated in 2003 with the EPA publication of guidance recommendations to States and Tribes on how they can designate uses and establish temperature numeric criteria for waterbodies to protect coldwater salmonid species in the Pacific Northwest. Although based on species in the Pacific Northwest, U.S. Environmental Protection Agency (2003) provides general guidance for salmonid temperature maximum conditions.

The EPA temperature recommendations are currently the most robust management targets for use in the Central Valley. The guidance is the result of a multi-year, multi-agency synthesis with contributions from three states, four federal agencies, five tribes, two public review drafts and two independent scientific peer review panels. The recommendations include a technical synthesis and detailed examinations of temperature impacts on salmonid behavior and distribution, spatiotemporal temperature patterns in streams, interactions with other factors, and a summary of the technical literature examining the physiological effects of temperature on salmonids, including consideration of California salmonid studies (Marine 1997; Marine and Cech Jr 1998; Myrick and Cech Jr 2000; Nielsen et al. 1994; Orsi 1971) as cited in (McCullough et al. 2001). There is a long standing precedent that U.S. Environmental Protection Agency (2003) represents the best available science for temperature recommendations and used in analyses in biological opinions (CVP/SWP operations for Sacramento, American, and Stanislaus rivers, Spring Creek) and FERC proceedings (Tuolumne River) in the Central Valley.

U.S. Environmental Protection Agency (2003) recommends a 13°C (55.4°F) maximum 7-day average of the daily maxima (7DADM) criterion for the protection of waterbodies used or potentially used for salmon and trout spawning, egg incubation, and fry emergence, and recommends that this use apply from the average date that spawning begins to the average date incubation ends (the first 7DADM is calculated one week after the average date that spawning begins). The 7DADM metric is recommended because it describes the maximum temperatures in a stream, but is not overly influenced by the maximum temperature of a single day. Thus, it reflects an average of maximum temperatures that fish are exposed to over a weeklong period.

Reclamation has noted that operating to the 7DADM metric is a less efficient use of the cold water pool because the week-long averaging period creates a lag between operations and the observed effect. However, without daily average temperature criteria derived from local temperature tolerance studies, the U.S. Environmental Protection Agency (2003) guidance provides the best available temperature tolerance criteria. The 7DADM of 55.4°F was used to identify an equivalent daily average temperature for use in management of temperature compliance. The Sacramento River at the Clear Creek gauge is a surrogate for the downstream extent of most winter-run Chinook salmon redds. The critical temperature threshold being used as a management target is 53.5°F daily average temperature, which was identified as an indicator of the ability to meet the 55°F 7DADM, and Rombough (1988) identified it as the temperature above which increased egg mortality is observed in steelhead eggs. A more recent phenomenological assessment of temperature-dependent Chinook salmon egg mortality modeling calibrated to fry survival to Red Bluff concluded the critical temperature threshold for egg incubation in the river was 53.6°F daily average. Below that temperature, there was no observed mortality due to temperature (Martin et al. 2017). According to a recent independent review panel, the model holds "…considerable potential for resolving important links between the physico-chemical environment (e.g., temperature and oxygen levels) experienced by the earliest life stages of salmonids and their survival in the Sacramento River," and is a "…realistic representation of temperature effects on eggs" (Gore et al. 2018). However, the same review also noted that "Despite its strengths... model predictions of survival will have sizable uncertainty...[and] further research is needed to eliminate other possible explanations..." and suggested "…that temperature-related mortality should be distinguished from all other sources of mortality through the fry stage." Based on the studies in the Central Valley, and on studies of temperature requirements for Chinook salmon, temperatures from 39.2 to 53.6°F tend to produce relatively high survival to hatching and emergence, with approximately 42.8-50°F being optimum (Boles 1988; Healey 1979; Myrick and Cech 2004; Seymour 1956; Slater 1963; U.S. Environmental Protection Agency 2001; U.S. Fish and Wildlife Service 1999). The egg temperature threshold of 53.5°F daily average temperature is also considered as the guidance establishing effects to CV spring-run Chinook salmon and CCV steelhead eggs and alevin.

To improve Sacramento River water temperature management for Chinook salmon, a 2016 pilot study was implemented where the temperature criterion was adjusted to the U.S. Environmental Protection Agency (2003) recommendation of 55°F 7DADM metric and applying it to the Bonneyview Bridge temperature control point which was roughly equivalent to a daily average temperature of 53.5°F at Clear Creek (Swart 2016).

The U.S. Environmental Protection Agency (2003) guidance also specifies a maximum of 61°F 7DADM for adult salmon holding prior to spawning and juvenile "core" rearing, and a summer maximum temperature for salmon/trout migration of 68°F 7DADM. As with salmonids, water temperature during the early life stages is a key factor in green sturgeon recruitment and development. The lethal temperature for developing eggs is approximately 22°C (71.5°F), with sublethal effects of abnormal development and reduced hatching success beginning to appear at 17.5°C (63.5°F) (Van Eenennaam et al. 2005).

Although our understanding of salmonid temperature tolerance continues to evolve since the publication of U.S. Environmental Protection Agency (2003), a comparably robust synthesis that includes more recent studies is lacking, and additional studies specific to Central Valley populations are still needed. For example, some more recent studies of rainbow trout have noted that that the physiological mechanisms that determine critical thermal maxima in salmonids are highly conserved (Rodnick et al. 2004) but also that populations may be locally adjusted to temperature differences (Verhille et al. 2016). One of the most recent studies on the topic built on the work of Martin et al. (2017), demonstrating plasticity in acute thermal tolerance, interactions with hypoxia, and potential physiological tradeoffs, ultimately concluding that "This study, in addition to Martin et al. (2017), suggests that in natural redds where dissolved oxygen (DO) is variable, the target temperature of 56°F may be too high in some cases since salmon egg mortality can occur at lower temperatures in hypoxia" (Del Rio et al. 2019). However, this study has not adequately distinguished between shorter term acclimatization to the local conditions versus adaptation via genetic change across a population, nor demonstrated how to derive robust ambient temperature targets from physiological endpoints like aerobic scope. A literature review by the University of California at Davis currently being prepared for publication concluded that for most life-stages and species for which thermal performance data exist, the U.S. Environmental Protection Agency (2003) guidelines appear to be protective against temperature-induced mortality for California salmonids. Although the guidelines may be sub-optimal and could use further refinement, in the absence of California-specific temperature guidance, the literature review recommended U.S. Environmental Protection Agency (2003) guidance for use in California (Zillig et al. 2018)."

In order to use the U.S. Environmental Protection Agency (2003) guidance in a meaningful way to assess the daily average temperatures described by Reclamation's HEC-5Q modeling, the 7DADM criteria need to be converted to monthly mean temperatures. Table 24 provides the conversion factors by month and location necessary to convert 7DADM to monthly mean temperatures that can be used to assess Reclamation's water operations effect on river temperatures.

Table 24. Conversion factors (°F) for seven-day average daily maximum water temperature thresholds to monthly mean temperatures for locations in the Sacramento River.

Month	Keswick	Clear Creek	Balls Ferry	Bend Bridge	Red Bluff	Wilkins Slough[1]
January	-0.36	-1.01	-0.75	-0.67	-0.86	0.0
February	-0.28	-1.11	-0.86	-0.62	-0.97	-0.3
March	-0.17	-1.29	-0.94	-0.66	-1.23	-0.3
April	-0.25	-1.66	-1.47	-0.95	-1.55	-0.6
May	-0.36	-1.73	-2.18	-1.59	-1.47	-1.4
June	-0.32	-1.55	-2.25	-1.87	-0.96	-1.2
July	-0.36	-1.41	-2.18	-2.01	-0.90	-1.3
August	-0.43	-1.74	-2.06	-1.61	-0.94	-1.3
September	-0.30	-2.00	-1.76	-1.16	-1.70	-2.0
October	-0.25	-1.73	-1.25	-0.91	-1.83	-1.4
November	-0.38	-1.37	-1.10	-0.99	-1.53	-1.3
December	-0.82	-1.42	-1.30	-1.24	-1.48	-1.0

Table excerpted from Appendix 5.D, Quantitative Methods and Details Results for Effect Analysis of Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale of the Biological Assessment for the California WaterFix (U.S. Bureau of Reclamation 2016a).
Based on historical data from 2003-2014 for all sites except Wilkins Slough, which is based on historical data from November 2012 through June 2015. For a given location and month, values in this table were added to 7DADM thresholds identified for the particular life stage such that actual thresholds used in the evaluation for each month were lower than those identified.
[1] *Because there is no flow gauge at Knights Landing, Wilkins Slough data were used to calculate the conversion factor for Knights Landing.*

While capturing the mean of conditions observed during the available historical data, these relationships are affected by water flow and may be different for specific flows. These relationships are applied in temperature assessments in subsequent sections of this Opinion to convert daily average HEC-5Q data into 7DADM.

Temperature effects associated with implementation of the tiered strategy are described according to the likelihood of Reclamation operating in a particular Tier (based on the modeled May 1 storage). While this Section describes the modeled likelihood of Reclamation operating to a particular "Tier" of summer cold water pool management, unforeseen events (e.g., reduced solar radiation from cloud or smoke cover, unusual Delta salinity conditions) can require a change of Tier within a year. NMFS relies on the modeled characterization of May 1 storage and temperature management conditions. NMFS has used the frequency of exposure to temperatures in the summer to characterize the effects. Moreover, because the proposed action includes full implementation of existing contracts including water contracts and agreements, water service and repayment, settlement contracts, exchange contracts, and refuge deliveries and is seeking take authorization for those contracts, this Opinion analyzes the effects of Reclamation's operations to meet those contract requirements on the likelihood of attaining temperature metrics. The conditions experienced by the species are then described by the likelihood of exceeding a temperature threshold within a Tier. In Section (), we identified uncertainties regarding the proposed action's ability to provide temperatures suitable for salmon holding, spawning, egg incubation and rearing from May 15 to October 31. In part, these uncertainties are attributed to the consideration of modeling limitations, alternative analytical tools, and real-time implementation of the proposed action. Figure 51 below shows examples of water temperatures at Clear Creek gauge for the four Tiers. The proposed Tiers are described below, along with storage levels that indicate the available cold water for each Tier.

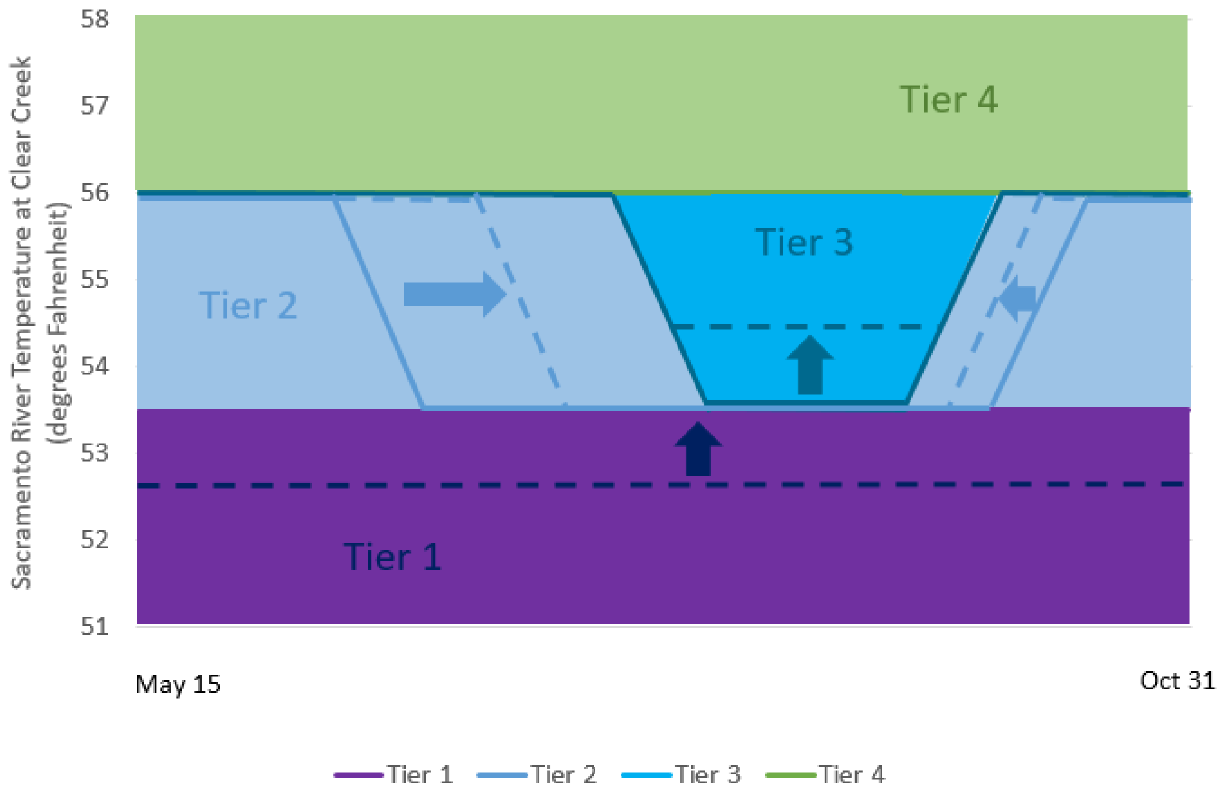


Figure 51. Depiction of temperature target operations according to Reclamation's tiered approach.

Source: ROC on LTO biological assessment (Figure 4-3)

Tier 1

Reclamation proposes to operate to a daily average temperature of 53.5°F at the Clear Creek gauging station in years when Reclamation determines that cold water pool is sufficient to manage summer temperatures (i.e., more than 2.8 million acre-feet of cold water pool in Shasta Reservoir at the beginning of May or modeling suggests that a daily average temperature of 53.5°F at Clear Creek gauge can be maintained from May 15 to October 31). A cold water pool volume of 2.8 million acre-feet approximates to 4.1 million acre-feet total storage at the end of April. Based on the CalSimII 82-year historic sample set, Shasta end of April storage is greater than or equal to 4.1 million acre-feet in 68.3 percent of years. However, under certain conditions, operations can change from one Tier to a higher Tier within a management season, and NMFS notes that Shasta Reservoir storages can change notably from May 1 to June 1 given early summer depletions and diversions.

The temperature modeling and tier selection would include assumptions of Shasta releases for these depletions and diversions and therefore would incorporate this change in storage. In addition, higher releases that extend all the way to the delta (such as for Delta exports or Delta outflow) help to improve temperatures and reduce warming during the hot summer. NMFS considers that Reclamation intends to use various operational flexibilities and/or contingency actions after May 1, potentially modifying deliveries to conserve coldwater pool, increasing flows to reduce warming or adjusting the balancing between Shasta and other CVP reservoirs, to stay within a Tier, unless the change is caused by events outside Reclamation's control or beyond what was planned for in the temperature management plan.

Tier 2

In years when cold water pool is insufficient to allow Tier 1 (i.e., less than 2.8 million acre-feet of cold water pool in Shasta Reservoir at the beginning of May or modeling suggests that the 53.5°F at Clear Creek gauge cannot be maintained from May 15 to October 31), Reclamation proposes to optimize use of cold water for protection of winter-run Chinook salmon eggs based on lifestage-specific requirements. This would reduce the duration of time operating to 53.5°F target temperatures compared to Tier 1. Water temperatures at Clear Creek gauge would vary based on real-time monitoring of redd timing and lifestage-specific temperature dependent mortality models such as Anderson (2018). The 53.5°F target temperature at Clear Creek gauge would be centered on the projected time period of greatest dissolved oxygen concentration requirement for winter-run Chinook salmon eggs (i.e., 37–67 days post-fertilization). When May 1 cold water pool is equal to or less than 2.79 million acre-feet, Reclamation proposes to operate to 53.5°F from 37 days after the first observed redd to 67 days after the last observed redd, as long as this is earlier than October 31. The duration of the 53.5°F protection will decrease in proportion to the available cold water pool on May 1; however, the proposed action does not specify the details of this decrease in duration. Reclamation will determine this time period by evaluating different temperature scenarios using the latest egg mortality model(s) and real-time monitoring of redds and discussing with Sacramento River Temperature Task Group where NMFS will be able to provide technical assistance. For the summer temperature management period outside of the lifestage-specific target, Reclamation proposes to operate to Clear Creek gauge daily average temperatures up to but no warmer than 56°F. Based on the CalSimII 82-year historic sample set, Shasta end of April storage is less than 4.1 million acre-feet, but greater than about 3.5 million acre-feet (equivalent to a cold water pool of 2.3 million acre-feet), in about 17 percent of years.

Tier 3

As identified in the proposed action, Reclamation may determine that the lifestage-specific temperature targets of Tier 2 cannot be met. Tier 3 is the proposed operation when cold water pool in Shasta Reservoir on May 1 is less than 2.3 million acre-feet or when modeling suggests that maintaining 53.5°F at Clear Creek gauge would have higher mortality than a warmer temperature. Reclamation proposes to use cold water pool releases to maximize winter-run Chinook salmon egg survival by increasing the coldest water temperature target.

In Tier 3, the targeted temperature at CCR during the early and late periods of cold water pool management will not exceed a daily average of 56°F. Based on latest egg mortality models, real-time monitoring, and expected and current cold water availability, Reclamation would decrease the temperatures during the period of greatest temperature stress on early life stages to minimize adverse effects to the greatest extent possible. During this critical period, temperatures will be targeted between 53.5°F and 56°F. Tier 3 will be selected if Reclamation's temperature management plan indicates that temperatures can be maintained to at least 56°F at CCR, otherwise Reclamation would operate to Tier 4. Because a lifestage-specific target is not explicitly defined, this component of the proposed action has a notable uncertainty in its effect to species. NMFS notes that the likely operational temperature target for this Tier has not yet been identified or proposed; it could range from 53.5°F to 56°F, and may even be no less than 56°F throughout the temperature season.

Based on the CalSimII 82-year historic sample set, Shasta end of April storage is less than 3.5 million acre-feet, but greater than about 2.5 million acre-feet, in about 7 percent of years. While NMFS can use this expectation in analyses of frequency of Tier 3 operations, we note that this may not be an accurate characterization of Tier probability and that operations can, in certain circumstances, change from one Tier to a higher tier within a management season.

Tier 4

Operations for Tier 4 are defined by mid-March storage and operations forecasts of Shasta Reservoir total storage less than 2.5 million acre-feet at the beginning of May, or if Reclamation cannot meet 56°F at Clear Creek gauge. In this instance, Reclamation proposes to initiate discussions with FWS and NMFS on potential intervention measures to address low storage conditions that continue into April and May (however, any benefits from implementation of these measures is not included in results presented below due to their inability to be characterized by the modeling). Reclamation proposes to perform an initial temperature model analysis in April after the DWR Bulletin 120 has been received and the operations forecast completed. This is the first month that a temperature model analysis is feasible based on temperature profiles. Prior to April, there is insufficient stratification in Shasta Reservoir to allow a temperature model to provide meaningful results. The April temperature model scenario is proposed to be used to develop an initial temperature plan for submittal to the State Water Resource Control Board. This temperature plan may be updated as Reclamation has improved data on reservoir storage and cold water pool via the reservoir profiles at the end of May, and throughout the temperature control season. NMFS notes that the proposed action indicates that the plan will be provided to the Sacramento River Temperature Task Group for review and comment, and NMFS assumes that the Sacramento River Temperature Task Group is the means by which NMFS would provide technical assistance to the development of this plan.

Based on the CalSimII 82-year historic sample set, Shasta end of April storage is less than 2.5 million acre-feet in about seven percent of years. While NMFS can use this expectation in analyses of frequency of Tier 4 operations, we note that this may not be an accurate characterization of Tier probability and that operations can, in some circumstances, change from one Tier to a higher Tier within a management season. This introduces uncertainty into the determination of effect of summer cold water pool management.

8.3.4.1.1 Winter-Run Chinook Salmon Exposure, Response, and Risk

Winter-run Chinook salmon response to the Summer Cold Water Pool Management component of the proposed action is largely associated with the biological requirement for water 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 53.5°F, there would be a decrease in egg survival. At temperature greater than 58°F, there would be an increase in pre-spawn adult mortality.

The Summer Cold Water Pool Management component of the proposed action is intended to coincide with 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 2015c).

In addition to the spatial and temporal distribution of redds, a critical consideration in assessing the effects of increased temperature on redds and eggs is the length of time a redd is sensitive to temperature increases as it relates to minimum dissolved oxygen concentration requirements. In consideration of potential management applications, Anderson (2018) assesses three models of temperature dependent mortality, where Model I (i.e. the Martin et al. (2017) model) considers age-independent thermal mortality with spatially-independent background mortality, Model II (i.e. the “Anderson model” used in this Opinion) considers age-dependent thermal mortality without any background mortality, and Model III which considers age-dependent thermal mortality and spatially-dependent background mortality. For this analysis Models I and II were considered, where the Anderson (2018) model assumes that redds/eggs are only sensitive to dissolved oxygen conditions in the five days before egg hatching (the “hatch model”), while the Martin et al. (2017) model considers temperatures and dissolved oxygen conditions from redd creation until fry emergence (the “emergence model”), which is a longer period. NMFS also considers that the Anderson model accounts for egg mortality only during the hatch period; background mortality and egg mortality resulting from higher water temperatures outside of the hatch period are not included in the application of this model. NMFS notes that the Anderson model could, therefore, underestimate mortality by not accounting for egg mortality prior to the hatch period in the calculated percentage mortality during the hatch period. NMFS also notes that the Anderson model is conceptual and has not been calibrated or peer reviewed. We acknowledge the uncertainties and needs for additional research identified in review of Martin et al. (2017), but also that it is a “realistic representation of temperature effects on eggs” (Gore et al. 2018). NMFS has considered external reviews and field-testing in discerning the weight of evidence applied to methods according to categories identified in Section 2.1 Analytical Approach. However, while NMFS considers the “emergence model” as representing the best available science for assessing temperature effects on salmonid eggs, to consider the effects of Shasta operations targeting the “hatch” period of egg development NMFS includes results for both models (hatch and emergence) in the following assessment. Inclusion of the Anderson (2018) “hatch model” results is exclusive to the assessment of Shasta temperature management, as the only action component of the proposed action based on Anderson (2018) are those related to Shasta operations.

Tier 1

Based on the CalSimII modeling of May 1 Shasta storage, Reclamation would determine that Tier 1 operations apply as an initial target to summer temperature management in approximately 68 percent of years. This is generally consistent with the frequency of Shasta storage greater than or equal to 4.1 million acre-feet on May 1 (Table 23). Increases in temperature projected by recent climate assessments (Section 2.1: *Analytical Approach*) are not reflected in these storage predictions.

HEC-5Q modeling of the proposed action indicates that during the temperature management seasons of Tier 1 years, the 53.5°F threshold is exceeded 23.3 percent of days. These results do not include real-time adjustments to operations that could allow Reclamation to reduce the proportion of days exceeding the temperature threshold at Clear Creek gauge. Regardless of those real-time decisions and the year categorizations, we consider the modeling provided to be the most quantitative approach to evaluating effects and have analyzed them as such. NMFS recognizes that the proposed action is expected to increase Shasta storage through various methods described at the beginning of this section, however uncertainties with the modeling make it difficult to precisely quantify this increase.

Exposure to Tier 1 years is characterized as a medium exposure of spawning adults and eggs to good temperature conditions, but is the highest exposure level relative to the other tiers. Exposure to temperatures exceeding 53.5°F is also considered a medium exposure but is the lowest of all tiers. Exposure to temperatures exceeding 53.5°F at Clear Creek gauge is expected to result in reduced reproductive success of individuals from reduced fecundity, or temperature-dependent egg mortality rates that are depicted in Figure 52.

The HEC-5Q results are inputs to both the Anderson and Martin egg mortality models. These results correspond to an estimated mean temperature dependent mortality in Tier 1 years of 5 percent and 6 percent for the Anderson and Martin models, respectively. The ranges of the 25th and 75th percentiles of results are zero to six percent for both models (Figure 52) and the standard deviations around the mean are ±8 and ±9 percent, respectively. These are averages of the dataset for the suite of Tier 1 years, which includes broad operational range.

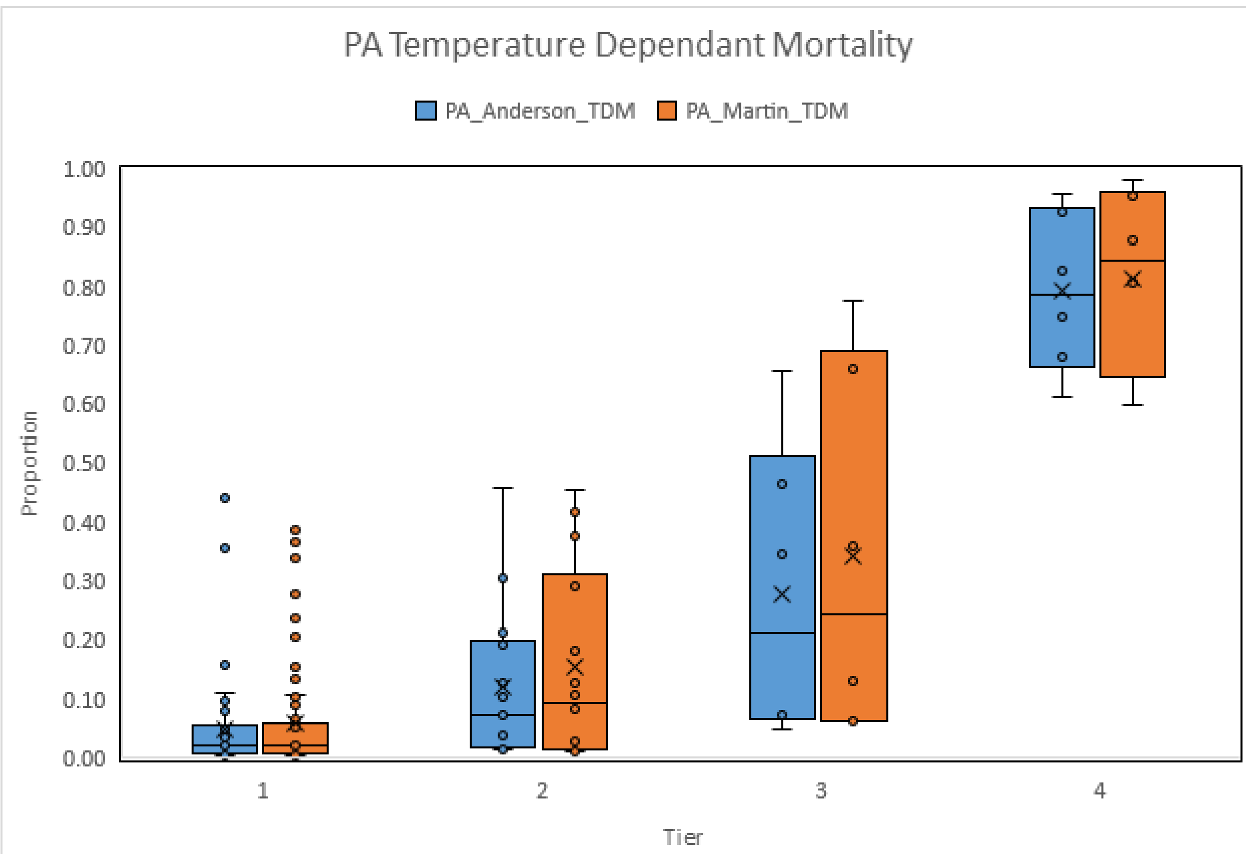


Figure 52. Temperature dependent mortality for each cold water temperature management Tier, as predicted for the Anderson model (blue) and the Martin model (orange).

Figures show the range of values between the 25th and 75th percentiles (shaded box), the mean (x mark) the median (horizontal bar), and the range of expected values (whiskers).

Tier 2

Based on the CalSimII modeling of May 1 Shasta storage, Reclamation would determine that Tier 2 operations apply as an initial early season target to summer temperature management in approximately 17 percent of years. However, NMFS analysis of historical data shows that the May 1 Shasta total storage would identify a Tier 2 year in as many as 35 percent of years. NMFS therefore considers the range of 17 to 35 percent of years. HEC-5Q modeling of the proposed action indicate that during the temperature management seasons of Tier 2 years, 53.5°F is exceeded 33.1 percent of days although the modeling does not capture real-time decision making which Reclamation expects will reduce the exceedance. This exposure corresponds to an estimated mean temperature dependent mortality in Tier 2 years of 12 percent and 15 percent for the Anderson and Martin models, respectively. The ranges of the 25th and 75th percentiles of results are 2 percent to 26 percent when considering both models (Figure 52), and the standard deviations around the mean are ±13 and ±16 percent, respectively. These are averages of the dataset for the suite of Tier 2 years, which includes a broad operational range; Figure 45 shows that outside of the lifestage-specific target, Tier 2 operations could result in temperatures as low as 53.5°F or as high at 56°F.

Exposure to Tier 2 years is characterized as a medium exposure of spawning adults and eggs to good temperature conditions, but is the second highest exposure level relative to the other tiers, and so could be considered a medium to high exposure in comparison to other tier frequencies. Exposure to temperatures exceeding 53.5°F is also considered a medium exposure but is the second lowest of all tiers. Exposure to temperatures exceeding 53.5°F at Clear Creek gauge is expected to result in reduced reproductive success of individuals from reduced fecundity, or temperature-dependent egg mortality rates that are depicted in Figure 53.

NMFS notes that Tier 2 operations are centered on the projected time period of greatest dissolved oxygen concentration requirement for winter-run Chinook salmon eggs. However, the approach does not consider the uncertainty regarding initiation of spawning given inherent imprecision of monitoring efforts, as previously stated. Timing of weekly (or less frequent) aerial redd surveys could result in miscalculating the onset of the hatch period by up to a week or more. Similar risks are associated with basing this approach on information from carcass surveys, which assume that redd construction occurs ten days prior to carcass detection. Therefore, the onset of temperature management could be seven or more days later than the actual onset of spawning. Reclamation has agreed to consider recommendations from Sacramento River Temperature Task Group to reduce risks associated with the variability in detection of the onset of spawning. The onset of spawning is especially important in the implementation of Tiers 2 and 3, when the proposed action proposes to center temperature management on the projected time period when the winter-run Chinook salmon eggs have the highest dissolved oxygen requirement. Because Tier 2 operations are proposed to be based on the timing of the hatch period, temperature-dependent egg mortality may be underestimated with the Tier 2 approach.

NMFS has evaluated associated side analyses to better consider the uncertainty associated with interpretation of the results of the different temperature-dependent egg mortality methods of the Anderson and Martin models. As proposed, temperatures outside of the lifestage-specific target time of Tier 2 could be as high as 56°F. A strict adherence to the warmest temperature time series defined by Figure 53 would result in temperatures at Clear Creek gauge of 56°F except during the lifestage-specific target period, during which temperatures would be 53.5°F. This is illustrated in the left plot of Figure 53.

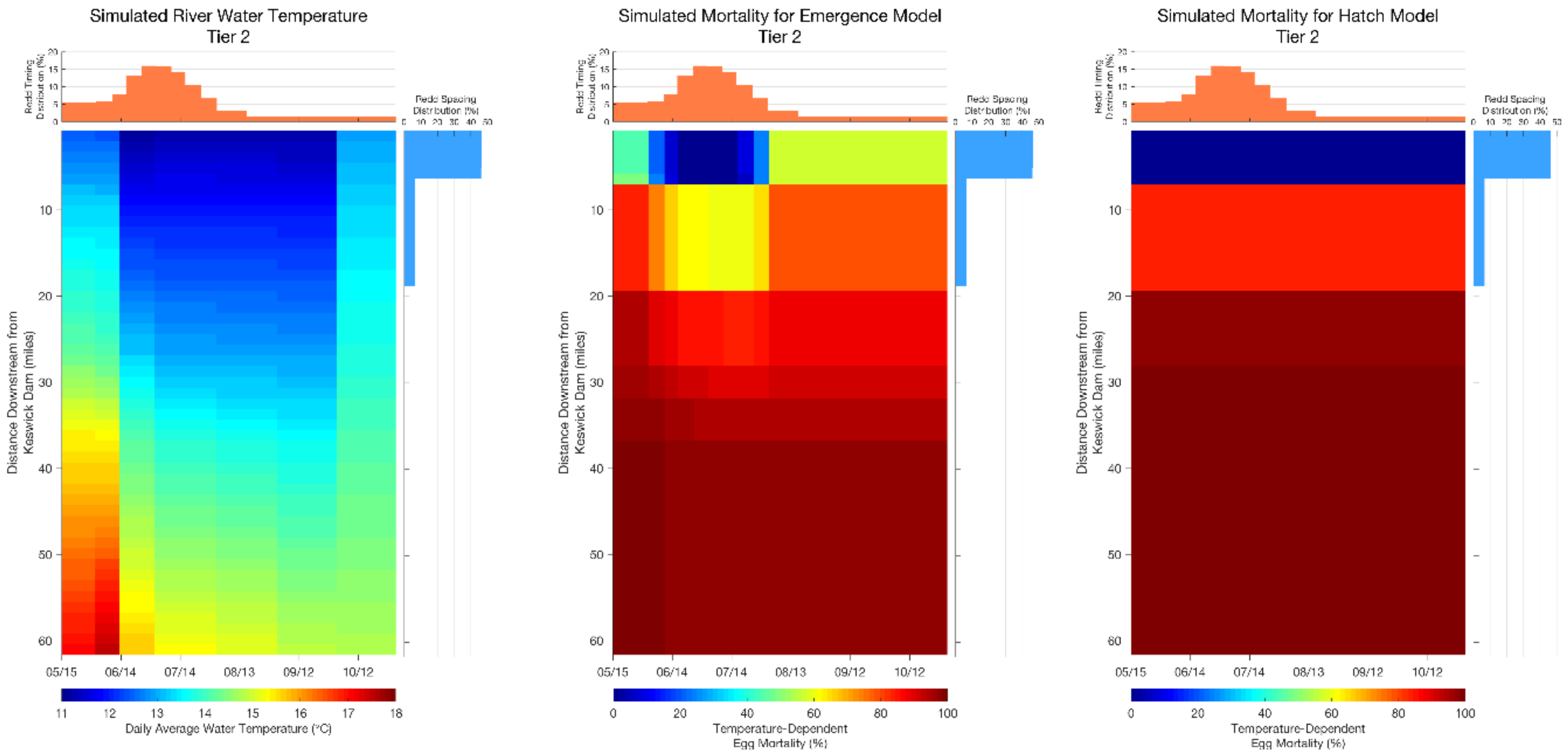


Figure 53. Simulated water temperature and temperature-dependent mortality in the upper Sacramento River for operation to highest temperatures within and outside of the lifestage-specific target period of Tier 2 summer temperature management.

The results of applying both the “emergence” and the “hatch” model to this temperature time series are shown in the middle and right plots of Figure 53. NMFS views this information as a worst-case characterization of a strict adherence to the warmest conditions allowed by the proposed operations defined for Tier 2, without moving to a different Tier during the summer temperature management season. It therefore serves as a contextual point of comparison of the range of effects that NMFS expects for years in which Tier 2 is maintained. NMFS notes that both models show lowest mortality during the “peak” of redd presence; the temperature-dependent mortality is less than 20 percent for both models in the mid-June through mid-July period. However, there is a notable discrepancy in the mortality for periods outside of this peak time of redd presence. The “emergence” model shows much greater temperature dependent mortality in the upper reaches earlier than mid-June and later than mid-July. Additionally, the hatch model estimates lower mortality in upper reaches than the emergence model, but greater mortality in lower reaches, where there are fewer redds (based on historical distribution). We note that the results of the emergence model shows mortality increases of nearly 60 percent in early August. This analysis shows the wide discrepancy for the different methods that have been used to assess effects of the operational range within a Tier. NMFS therefore considers the results of both models in our analysis and in support for understanding the difference in ranges of results shown in Figure 52.

Tier 3

Based on the CalSimII modeling of May 1 Shasta storage, Reclamation would determine that Tier 3 operations apply as an initial early season target in approximately 7 percent of years. However, NMFS analysis of historical data shows that the May 1 Shasta total storage would identify a Tier 3 year in as many as 15 percent of years. NMFS therefore considers the range of 7 to 15 percent of years. HEC-5Q modeling of the proposed action indicates that during the temperature management seasons of Tier 3 years, 53.5°F is exceeded 65 percent of days, although the modeling does not capture real-time decision making which Reclamation expects will reduce the exceedance. This exposure corresponds to an estimated temperature-dependent mortality in Tier 3 years of 28 percent and 34 percent for the Anderson and Martin models, respectively. The ranges of the 25^{th} and 75^{th} percentiles of results are 7 to 59 percent when considering both models (Figure 52), and the standard deviations around the mean are ±25 and ±31 percent, respectively. These are averages of the dataset for the suite of Tier 3 years, which includes a broad operational range. The proposed action indicates and Figure 53 shows that Tier 3 operations could result in temperatures as low as 53.5°F or as high at 56°F, the lifestage-specific target may shift based on storage conditions, and the operational Tier could shift to Tier 4 during the summer temperature management season.

Exposure to Tier 3 years is characterized as a medium exposure of spawning adults and eggs to good temperature conditions, but is the third lowest exposure level relative to the other tiers, and so could be considered a low exposure in comparison to Tier 1 and 2 frequencies. Exposure to temperatures exceeding 53.5°F is also considered a medium exposure but is the third highest of all tiers. Exposure to temperatures exceeding 53.5°F at Clear Creek gauge is expected to result in reduced reproductive success of individuals from reduced fecundity, or temperature-dependent egg mortality rates that are depicted in Figure 53.

In evaluating effects of Tier 3, NMFS considered knowledge gained from operations in recent dry years. Due to a lack of sufficient cold water pool in Shasta Reservoir in 2015, Sacramento

River water temperatures rose to sublethal and lethal levels contributing to very low egg-to-fry survival of juvenile winter-run Chinook salmon estimated to pass Red Bluff Diversion Dam in brood year 2015 (4.2 percent), well below the 18-year average of 23.6 percent survival.

For 2015, May 1 storage of approximately 2.66 million acre-feet would have arguably required designation of a Tier 3 management approach. While an initial May temperature management plan was established for that season, warmer temperatures and reduced inflow required that the plan be revised. The revised plan targeted a temperature of 57°F at the Clear Creek gauge (not to exceed 58°F unless required to conserve cold water pool based on real-time temperature management team guidance). The resulting average daily temperatures at Clear Creek gauge for the 2015 temperature management season of May to October was 56.7°F (Figure 54); these conditions resulted in a modeled winter-run Chinook salmon temperature-dependent survival of 14.6 percent (or conversely, 85.4 percent temperature-dependent mortality) and an observed egg to fry survival of 4.2 percent (National Marine Fisheries Service 2017c). Figure 55 shows a hindcast of the temperature landscape and temperature-dependent mortality conditions for 2015 downstream of Keswick Dam. These figures show that despite an end of April storage indicating a Tier 3 management approach, which biological assessment modeling suggests would be expected to result in mean temperature-dependent mortality of 34 percent and 63 percent for the Anderson and Martin models, respectively, the proportion of redds exposed to temperatures in excess of 56°F was significantly larger.

The modeling from the biological assessment showed high expected mortality in the worse of the Tier 3 years. The proposed action includes a description of intervention measures intended to minimize or mitigate the effects of conditions and operations associated with the Tier 4 years. If the temperature management plan indicates that the tier 3 year may result in higher fall temperatures, the intervention measures will also be implemented. These measures would include consulting with USFWS and NMFS, increasing hatchery intake, adult rescue, and juvenile trap and haul.

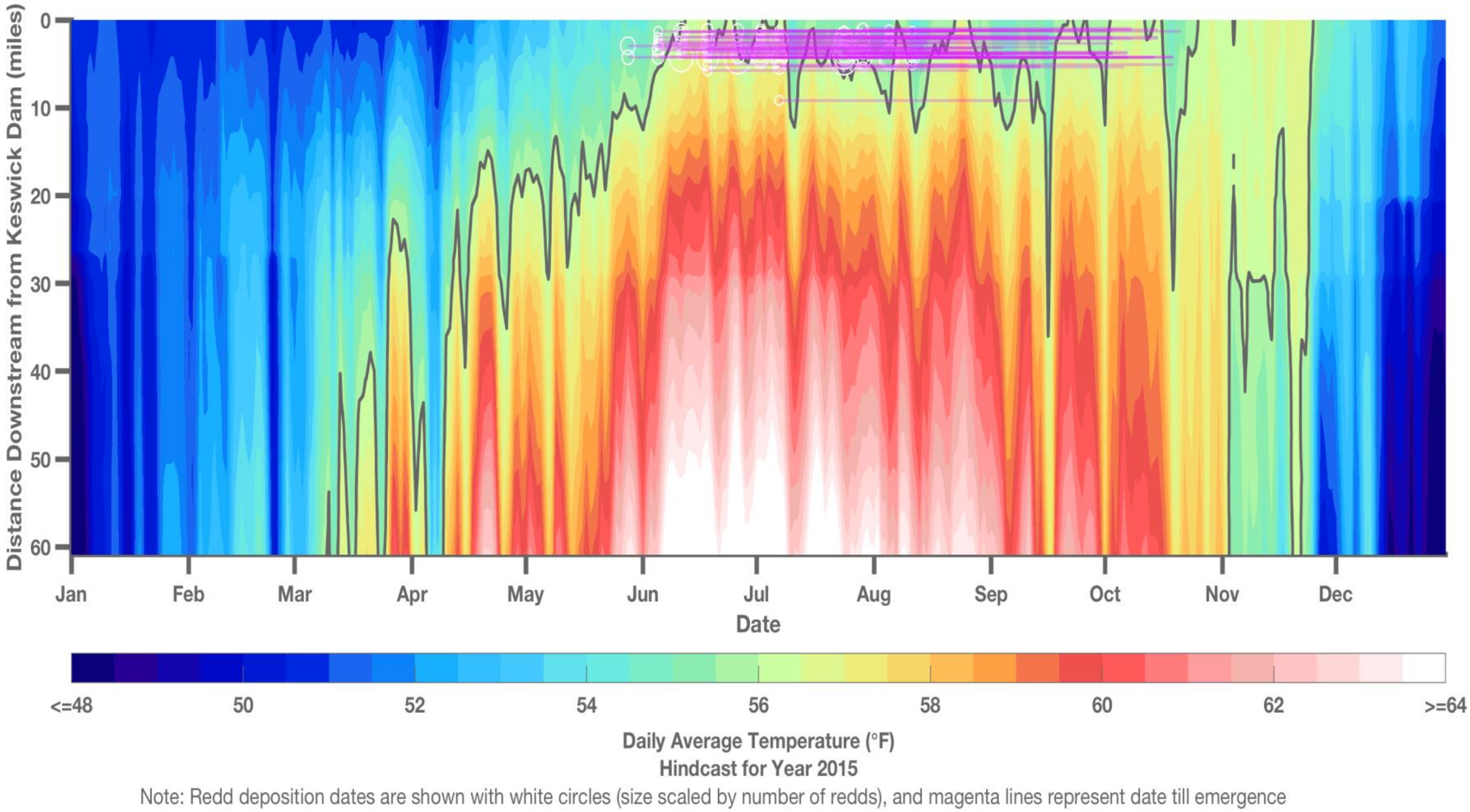


Figure 54. Hindcasted water temperature (°F) landscape plots for 2015 downstream of Keswick Dam. Redd deposition dates are shown with white circles (size scaled by number of redds) and magenta lines represent data until emergence.

Source: SWFSC

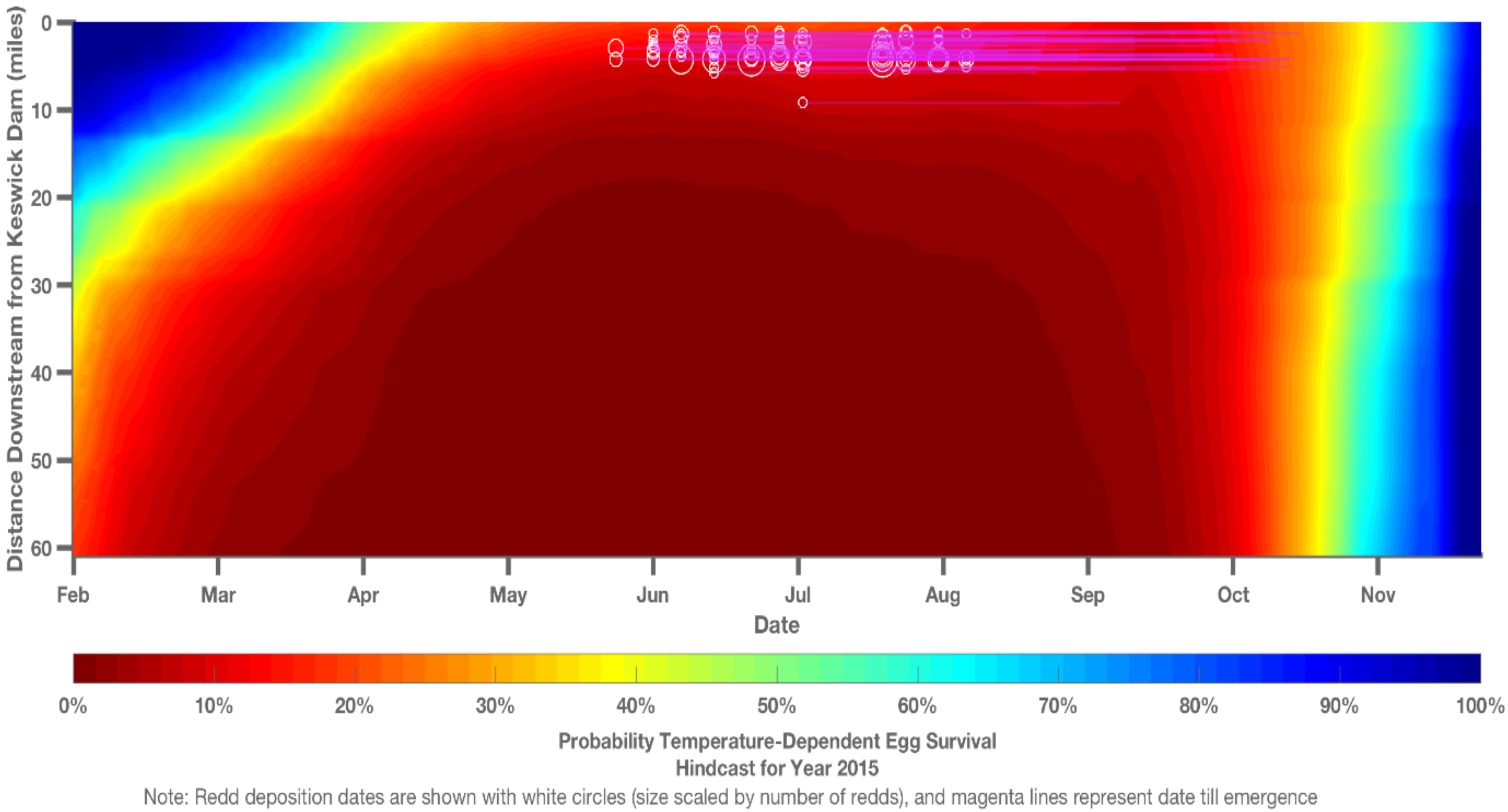


Figure 55. Hindcasted temperature-dependent mortality landscape plots for 2015 downstream of Keswick Dam. Redd deposition dates are shown with white circles (size scaled by number of redds) and magenta lines represent data until emergence.

Source: SWFSC

Tier 4

Based on the CalSimII modeling of May 1 Shasta storage, Reclamation would determine that Tier 4 operations apply as an initial early season target in approximately seven percent of years. NMFS analysis of historical data shows that the May 1 Shasta total storage would identify a Tier 4 year in as many as five percent of years. NMFS therefore considers the range of five to seven percent of years. HEC-5Q modeling of the proposed action indicates that during the temperature management seasons of Tier 4 years, 53.5°F is exceeded 86 percent of days. This exposure corresponds to an estimated temperature-dependent mortality in Tier 4 years of 79 percent and 81 percent for the Anderson and Martin models, respectively. The ranges of the 25th and 75th percentiles of results are 70 to 93 percent when considering both models (Figure 52), and the standard deviations around the mean are ±14 and ±16 percent, respectively.

Exposure to Tier 4 years is characterized as a medium exposure of spawning adults and eggs to good temperature conditions, but is the lowest exposure level relative to the other tiers. Exposure to temperatures exceeding 53.5°F is also considered a large exposure and is the highest of all tiers. Exposure to temperatures exceeding 53.5°F at Clear Creek gauge is expected to result in reduced reproductive success of individuals from reduced fecundity, or temperature-dependent egg mortality rates that are depicted in Figure 55. The proposed action includes description of intervention measures intended to minimize or mitigate the effects of conditions and operations associated with the Tier 4 years. These measures would be triggered by low storage conditions and include consulting with FWS and NMFS, increasing hatchery intake, adult rescue, and juvenile trap and haul.

8.3.4.1.2 CV Spring-Run Chinook Salmon Exposure, Response, and Risk

As with winter-run Chinook salmon, CV spring-run Chinook salmon response to the Summer Cold Water Pool Management component of the proposed action is primarily associated with temperature. Temperatures above the 61°F 7DADM threshold for salmon adult 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 egg survival (U.S. Environmental Protection Agency 2003). Temperatures above the 53.5°F threshold would cause decreased egg survival (Water Temperatures stressor).

The start of the Summer Cold Water Pool Management 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 ten 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 five percent will have passed (Vogel and Marine 1991). Adult migration into the Sacramento River tributaries of 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. CV 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 Cold Water Pool Management.

Tier 1

The likelihood of Reclamation implementing Tier 1 operations for Summer Cold Water Pool Management for CV spring-run Chinook salmon is the same as it is for winter-run Chinook salmon. NMFS notes that HEC-5Q modeling of the proposed action indicates that during the temperature management seasons of Tier 1 years, the 61°F threshold for salmon adult holding prior to spawning is not exceeded during the temperature management season (May 15 - October 31) at Balls Ferry. As discussed earlier, the 61°F threshold is based on the 7DADM criteria described in U.S. Environmental Protection Agency (2003) Region 10 water quality guidance. The 7DADM temperature roughly equates to a daily average temperature threshold that ranges between 2.25 - 1.25°F cooler, as shown in Table 24. With the converted daily average temperature, HEC-5Q modeling results indicate that during the temperature management seasons of Tier 1 years, the DAT threshold at Balls Ferry for salmon adult holding prior to spawning is exceeded in about 1 percent of days. Modeled temperatures during the CV spring-run Chinook salmon spawning period (August – October) indicate that during the temperature management season of Tier 1 years, the 53.5°F threshold is exceeded 76 percent of days at Balls Ferry, which we consider to represent the downstream extent of CV spring-run Chinook salmon spawning.

Tier 2

As described for winter-run Chinook salmon, Reclamation would determine that Tier 2 operations apply as an initial early season target in approximately 17 percent of years. HEC-5Q modeling of the proposed action indicates that during the temperature management seasons (May 15 - October 31) of Tier 2 years, adult CV spring-run Chinook salmon migrating and holding prior to spawning would be exposed to temperatures in excess of the 61°F 7DADM threshold at Balls Ferry (when converted to a DAT threshold) in about 1 percent of days in Tier 2 years. Over the course of the spawning season (August – October) modeling shows CV spring-run Chinook salmon redds are exposed to temperatures greater than the egg incubation threshold of 53.5°F in about 80 percent of days during Tier 2 operations. NMFS notes that this is only four percentage points greater than the probability of exposure to temperatures greater than 53.5°F during Tier 1 years.

Tier 3

As described for winter-run Chinook salmon, Reclamation would determine that Tier 3 operations apply as an initial early season target in approximately 7 percent of years. The HEC5Q modeling of the proposed action indicates that during the temperature management seasons (May 15 - October 31) of Tier 3 years, adult CV spring-run Chinook salmon migrating and holding prior to spawning would be exposed to temperatures in excess of the 61°F 7DADM threshold at Balls Ferry (when converted to a DAT threshold) in about 13 percent of days in Tier 3 years. Over the course of the spawning season (August – October) modeling shows CV spring-run Chinook salmon redds are exposed to temperatures greater than the egg incubation threshold of 53.5°F in about 97 percent of days at Balls Ferry.

Tier 4

As described for winter-run Chinook salmon, Reclamation would determine that Tier 4 operations apply as an initial early season target in approximately 7 percent of years. The HEC-5Q modeling of the proposed action indicates that during the temperature management seasons (May 15 - October 31) of Tier 4 years, adult CV spring-run Chinook salmon migrating and holding prior to spawning would be exposed to temperatures in excess of the 61°F 7DADM threshold at Balls Ferry (when converted to a DAT threshold) in about 36 percent of days in Tier 4 years. During the spawning period (August – October) modeling shows CV spring-run Chinook salmon redds are exposed to temperatures greater than the egg incubation threshold of 53.5°F in about 100 percent of days at Balls Ferry.

8.3.4.1.3 CCV Steelhead Exposure, Response, and Risk

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 ten 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 Cold Water Pool Management.

Tier 1

The likelihood of Reclamation implementing Tier 1 operations for Summer Cold Water Pool Management for CCV steelhead is the same as it is for winter-run Chinook salmon. HEC-5Q modeling of the proposed action indicates that during the temperature management seasons of Tier 1 years, the threshold temperature of 61°F 7DADM for juvenile rearing, when converted to DAT, is exceeded in 23 percent of days at Red Bluff Diversion Dam from May 15 to October 31. For adult CCV steelhead migration, the threshold of 68°F is not exceeded at Red Bluff Diversion Dam in Tier 1 years during this period.

Tier 2

As described for winter-run Chinook salmon, Reclamation would determine that Tier 2 operations apply as an initial early season target in approximately 17 percent of years. HEC-5Q modeling of the proposed action indicates that during the temperature management seasons of Tier 2 years, the threshold temperature of 61°F 7DADM for juvenile rearing, when converted to DAT, is exceeded at Red Bluff Diversion Dam in 35 percent of days from May 15 to October 31. For returning adult CCV steelhead, the migration temperature threshold of 68°F is not exceeded at Red Bluff Diversion Dam in Tier 2 years during this period.

Tier 3

As described for winter-run Chinook salmon, Reclamation would determine that Tier 3 operations apply as an initial early season target in approximately seven percent of years. HEC-5Q modeling of the proposed action indicates that during the temperature management seasons of Tier 3 years, the threshold temperature for of 61°F for juvenile rearing, when converted to daily average temperature, is exceeded at the Red Bluff Diversion Dam in 65 percent of days from May 15 to October 31. For returning adult CCV steelhead, the migration temperature threshold of 68°F would be exceeded in about one percent of days at Red Bluff Diversion Dam in Tier 3 years during this period.

Tier 4

As described for winter-run Chinook salmon, Reclamation would determine that Tier 4 operations apply as an initial early season target in approximately seven percent of years. The HEC-5Q modeling of the proposed action indicates that during the temperature management seasons of Tier 4 years, the threshold temperature of 61°F for juvenile rearing, when converted to daily average temperature, would be exceeded at the Red Bluff Diversion Dam in about 77 percent of days from May 15 to October 31. For returning adult CCV steelhead, the migration temperature threshold of 68°F would be exceeded at Red Bluff Diversion Dam in less than 15 percent of days May 15 to October 31. Temperature exceedances above the 61°F 7DADM EPA Region 10 threshold for juvenile CCV steelhead rearing could cause a competitive disadvantage with other fish, or elevated disease rates.

8.3.4.1.4 Green Sturgeon Exposure, Response, and Risk

The timing of summer cold water pool management is such that it coincides with the peak of egg, larval, and juvenile green sturgeon presence in the upper Sacramento River. Occurring from April to July, green sturgeon spawning in the Sacramento River extends from Cottonwood Creek just downstream of Balls Ferry to Hamilton City (Poytress et al. 2015).

Sacramento River temperature management was rated as a medium threat to all life stages of sDPS green sturgeon. Under laboratory conditions, Mayfield and Cech (2004) reported optimal bio-energetic performance of age-0 and age-1 Northern DPS green sturgeon at 59 to 66°F (15 to 19°C). Summer water temperatures in the upper Sacramento River have typically been below this range, within lab-based optima for green sturgeon egg development but below lab-based optima for green sturgeon larval and juvenile growth (Allen et al. 2006; Mayfield and Cech 2004; Van Eenennaam et al. 2005). Notably, temperatures throughout the upper Sacramento River were in excess of 56°F (13.3°C) during periods of 2014 and 2015 due to historic drought but the effect of this on sDPS green sturgeon production remains unclear. Although the first successful season of directed juvenile green sturgeon sampling near Red Bluff Diversion Dam occurred during elevated temperatures in 2015, juveniles were subsequently collected in 2016 and 2017 sampling efforts (As cited in National Marine Fisheries Service 2018f). Furthermore, high larval sDPS green sturgeon catch at Red Bluff Diversion Dam has occurred in years with relatively low water temperatures (1995, 2011, 2016, and 2017; as cited in National Marine Fisheries Service (2018f)). The effect of cold-water releases from Keswick Dam may have a greater impact on green sturgeon spawning and incubation in the uppermost accessible reach of the Sacramento River below the Anderson-Cottonwood Irrigation District Dam. The Anderson-Cottonwood Irrigation District Dam is considered as a migration barrier for sturgeon, but low water temperature could deter green sturgeon spawning even if passage was restored to this reach.

Tier 1

As described for winter-run Chinook salmon, Reclamation would determine that Tier 1 operations apply as an initial early season target in approximately 68 percent of years based on the CalSimII modeling. Tier 1 operations are not expected to have a lethal effect on sDPS of green sturgeon eggs based on the HEC-5Q modeling of the proposed action which indicates that during Tier 1 years, the threshold temperature of lethal effect (71.5°F) is not exceeded at Hamilton City from May 15 to October 31. Sublethal effects would be expected in Tier 1 years;

31 percent of Tier 1 days exceed the threshold of 63.5°F at Hamilton City from May 15 to October 31.

Tier 2

As described for winter-run Chinook salmon, Reclamation would determine that Tier 2 operations apply as an initial early season target in approximately 17 percent of years. HEC5Q modeling of the proposed action indicate that during Tier 2 years, the threshold temperature of 71.5°F for egg mortality is not likely to be exceeded at Hamilton City during May 15 to October 31. Sublethal effects would be expected in Tier 2 years; 42 percent of Tier 2 days exceed the threshold of 63.5°F at Hamilton City from May 15 to October 31.

Tier 3

As described for winter-run Chinook salmon, Reclamation would determine that Tier 3 operations apply as an initial early season target in approximately seven percent of years. HEC-5Q modeling of the proposed action indicate that during Tier 3 years, the threshold temperature of 71.5°F for egg mortality is exceeded in less than one percent of days at Hamilton City during May 15 to October 31. Sublethal effects are expected in Tier 3 years; 67 percent of Tier 3 days exceed the threshold of 63.5°F at Hamilton City from May 15 to October 31.

Tier 4

As described for winter-run Chinook salmon, Reclamation would determine that Tier 4 operations apply as an initial early season target in approximately seven percent of years. HEC-5Q modeling of the proposed action indicate that the threshold temperature of 71.5°F for egg mortality is exceeded in eight percent of Tier 4 days at Hamilton City from May 15 to October 31. Sublethal effects are expected in Tier 4 years; 74 percent of Tier 4 days exceed the threshold of 63.5°F at Hamilton City during May 15 to October 31.

Based on the temperature thresholds of the early life stages of this species and the predicted range of Tier 4 water temperatures in the upper Sacramento River during the temperature management season, the proposed action would be expected to negatively affect the growth, or survival of sDPS green sturgeon eggs and alevin.

8.3.4.2 Annual Temperature Management Plan

Revisions to the Summer Cold Water Pool Management section of the biological assessment (U.S. Bureau of Reclamation 2019c) include a description of the process for development of an annual temperature management plan, including use of conservative forecasts and NMFS participation through the Sacramento River Temperature Task Group.

Compared to the previous analysis, this revision decreases the uncertainty of operations being able to stay within the determined Tier for the duration of the temperature management season. With this change, we consider our previous analysis of the modeled outcomes of temperature management – which, due to limitations of the models, do not explicitly mimic the process of developing a temperature management plan by projecting stream temperatures through summer for various management scenarios – to be more accurate in characterizing the likelihood of maintaining the determined Tier of projected and expected operations. That is, given the commitment to develop a temperature management plan based on conservative meteorology, hydrology, and inflows, we consider it more likely that the operations will stay within the determined Tier throughout the season, which is what is reflected in the modeling and analysis.

We do not have quantitative support to indicate exactly how any results described in Section 8.3.4: *Shasta Summer Operations* would change in response to this revision. Given the inability to quantify this reduction and NMFS' adherence to the precautionary principle we still consider the results above as the best quantitative characterization of the exposure of the species to the stressor of increased water temperature and the risk based on the expected long-term proportion of years in each Tier type. NMFS considered that the temperature management plan may reduce the likelihood of exceeding the temperature target, which is used in the characterization of exposure to increased temperatures in the previous analysis.

8.3.4.3 Commitment to Cold Water Management Tiers

The addition of the Commitment to Cold Water Management Tiers section of the final proposed action includes definition of commitments to the cold water management tier identified at the beginning of the temperature management season and actions required if a change in Tier is required.

Compared to the previous analysis, this revision decreases the uncertainty of operations moving to a different Cold Water Management Tier during the temperature management season. With this change, we consider our previous analysis of the modeled outcomes of temperature management – which do not incorporate mid-season changes to a different Tier – to be an accurate characterization of projected and expected operations. The results described previously will not change quantitatively, as this commitment to maintaining the determined Tier and required actions upon changes in Tier do not affect the modeling results used to characterize the exposure of the species to the stressor of increased water temperature, or the risk based on the expected long-term proportion of years in each Tier type.

The proposed action revisions include the action of chartering an independent panel in the case that Reclamation moves to a warmer Tier during the temperature management season. This will improve the understanding of what conditions or operations contributed to the need to change Tiers, and help inform future operations, although a post-hoc evaluation does not result in real-time protections to the species.

8.3.4.4 Upper Sacramento Performance Metrics

Revisions to the Cold Water Pool Management section of the final proposed action includes the addition of Upper Sacramento Performance Metrics. The objective of these performance metrics is to ensure that the conditions that manifest as a result of operations within a tier reflect the modeled range, and show a tendency towards performing at least as well as the distribution produced by the simulation modeling of the proposed action. It includes tracking of both temperature dependent mortality and egg-to-fry survival over time with the objective of completing annual and multi-year hindcast evaluations of the ability to meet the survival objectives and of the expectation that hydrology will occur as identified by the probabilities in the modeling. The metrics also include identification of expected improvement of egg-to-fry survival from habitat restoration projects recently completed, currently underway, or proposed to be completed by year 2030 (the duration of the proposed action). The additions identify drought and dry year actions and annual reporting, along with hindcast analysis of survival to identify if results are within the central tendency of modeled and analyzed results. The text also describes the process for chartering independent reviews, including established timelines, triggers, and focus topics.

Compared to the previous analysis, this addition to the Cold Water Pool Management section contributes to increasing the certainty that the central tendency of the analyzed results is what the species will experience when these operations are implemented. That is, the analysis characterized exposure and risk based on the central statistics of modeled temperature dependent mortality for each Tier type and the long-term projected likelihood of occurrence of each year type. However, the temperature dependent mortality results included a broad range for each Tier due to the variability of conditions included in each Tier type. The results described in Section 8.3.4: *Shasta Summer Operations* will not change quantitatively, as this commitment to assess cold water management does not affect the modeling results used to characterize the exposure of the species to the stressor of increased water temperature, or the risk based on the expected long-term proportion of years in each Tier type.

8.3.4.5 Drought and Dry Year Actions

Revisions to the Governance section of the proposed action includes the addition of Section 4.12.5 Drought and Dry Year Actions to develop a toolkit of actions to be taken in drought conditions, and a process by which early warnings of drought conditions may allow for clear and swift development of a drought contingency plan.

Our previous analysis of the modeled outcomes of temperature management still applies as a conservative characterization of projected and expected operations. The results described in Section 2.5.2.3.3.1 Summer Cold Water Pool Management could slightly over-represent a high mortality event that could be prevented by this Drought and Dry Year Action; however, the results of the modeling would not predictably change the exposure of the species to the stressor of increased water temperature, or the risk based on the expected long-term proportion of years in each Tier type. Compared to the previous analysis, the addition of the drought and dry year actions decreases the uncertainty associated with high mortality values modeled for Tier 3 and Tier 4 years. NMFS expects that any actions taken in this instance would increase the likelihood that resulting mortality values would be minimized to the extent possible.

8.3.4.6 Collaboration during Tier 3 and Tier 4 Scenarios

The commitment from the SRS Contractors to meet and confer during Tier 3 and Tier 4 years further decreases the uncertainty associated with high mortality values modeled for Tier 3 and Tier 4 years. NMFS expects that any actions taken would increase the likelihood that resulting mortality values would be minimized to the extent practicable, particularly for winter-run Chinook salmon. Additionally, delayed diversions for rice decomposition during the fall months could provide increased reliability that target flows would be met according to the Fall and Winter Refill and Redd Maintenance operations for building storage and reducing the effects of flow fluctuations.

8.3.4.7 Chartering of Independent Panels and Four Year Reviews

Revisions to the Governance section of the proposed action include the addition of Section 4.12.6 Chartering of Independent Panels and Section 4.12.7 Four-Year Reviews to charter reviews either at set dates or as triggered. The review topics are expected to include the Upper Sacramento Performance Metrics and associated topics in that section. The reviews will be greatly informative in increasing the understanding of effects of temperature conditions and operational decisions on species response in the years following the review. The results described previously will not change quantitatively, as this commitment to assessing the performance of the proposed action does not affect the modeling results used to characterize the exposure of the species to the stressor of increased water temperature, or the risk based on the expected long-term proportion of years in each Tier type. The panel's recommendations may result in modification to improve summer cold water pool management in future years, which are within the agencies' authorities.

8.3.5 Shasta Fall Operations

Fall (October-November) operations are dominated by temperature control and the provision of adequate fish spawning habitat. By fall, the remaining cold water pool in Shasta Reservoir is usually limited.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. These two conditions force consideration of the operational tradeoffs between maintaining high flows for the fall temperature management versus reducing flows to conserve storage for the following year's temperature management. Reclamation's objective during the fall period (and often late summer) is to decrease Keswick releases to a lower level in order to conserve and build storage. Reclamation is limited in its ability to reduce releases and build 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 State Water Resource Control Board Delta requirements.

8.3.5.1 Fall and Winter Refill and Redd Maintenance

As part of Shasta fall operations, Reclamation proposes to rebuild reservoir storage and cold water pool for the subsequent year by limiting the number of years that high fall releases are maintained. By basing late fall and winter releases from Keswick on end of September storage, Reclamation strives to obtain a balance between maintaining releases to keep late-spawning winter-run Chinook salmon redds underwater and not drawing down storage necessary for temperature management in the subsequent year. Reclamation proposes to consider these competing needs with a risk analysis as in the proposed action:

> "Reclamation will minimize effects with a risk analysis of the remaining winter-run Chinook salmon redds, the probability of sufficient cold water in a subsequent year, and a conservative distribution and timing of subsequent winter-run Chinook salmon redds. If the combined productivity of the remaining redds plus a conservative scenario for the following year is less than the productivity of maintaining releases, Reclamation will reduce releases to rebuild storage. The conservative scenario for the following year would include a 75 percent (dry) hydrology; 75 percent (warm) climate; a median distribution for the timing of redds, and the ability to remain within Tier 3 or higher (colder) Tiers."

If, based on the above risk analysis, Reclamation determines releases need to be reduced to rebuild storage, targets for winter base flows (December 1 through end of February) from Keswick would be determined in October and would be based on the previous month's Shasta

Reservoir end of September storage. The October and November release targets would be determined according to biological assessment Table 4-9 and revised to improve refill capabilities for Shasta Reservoir to build cold water pool for the following year. During the risk analysis, Reclamation will also consider the potential impact of reducing flows on dewatering late spawning winter-run Chinook redds and juvenile stranding. During the recent period of implementation of the NMFS 2009 Opinion (2010-2018), Reclamation worked with the Sacramento River Temperature Task Group and other agencies to minimize redd dewatering and it is anticipated that the Sacramento River Temperature Task Group will continue to provide interagency technical assistance. Although this interagency coordination is expected to improve Reclamation's real-time operational decisions and reduce impacts, for this analysis the modeled results of Shasta end of September and fall flows provided by CalSimII represent the results of the risk analysis and operational criteria. The likelihood of Reclamation implementing a particular release schedule is reflected in the proportion of years that Shasta end of September storage is less than or equal to 2.2 million acre-feet. For the proposed action, CalSimII modeling indicates that Shasta end of September storage is less than 2.2 million acre-feet in 20 percent of years.

Based on the proposed action, 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. Relative to the flows of the current operating scenario, CalSimII modeling of the proposed action shows very small differences in monthly average releases from Keswick for the reach downstream to Bend Bridge in the fall and winter. For the period of October through the end of February, the CalSimII modeling of the proposed action shows that releases are generally expected to provide similar flows in the upper reach of the Sacramento River with the exception of the month of November (ROC on LTO biological assessment Appendix D Table 15-3). During above normal and wet years, flows in November are higher in the current operating scenario than in the proposed action indicating the Shasta storage is being conserved.

Low flows during the late fall and winter have a negative effect on downstream migration of juvenile salmonids. A recent assessment of mark-recapture survival models in the Sacramento mainstem 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; Michel et al. 2015; Zeug et al. 2014). Likewise, 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 water flow 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 winter-run Chinook salmon outmigration 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 are such that a review of coded wire tag recovery data for winter-run, late-fall-run, and fall-run Chinook salmon showed annual SAR estimates of less than 1 percent. For winter-run Chinook salmon, the mean smolt-to-adult ration from 1999 to 2012 was 0.64 (standard error of 0.18), well below the Columbia River Basin Fish and Wildlife Program suggested minimum of 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, low reservoir releases to help build storage for the following temperature management season has a negative effect on downstream migration and survival. When these reduced flows lead to building more storage, they also allow Reclamation to meet the flood control maximum elevations more often and make earlier (or more frequent) flood control releases. The biological assessment shows increased releases from Keswick in the wetter years for both December and January, indicating that the low flows are not always experienced throughout the entire fall and winter period. The resultant low fall and winter flows in the proposed action contribute to the low winter-run Chinook salmon smolt-to-adult ratio, estimates of which are below population survival and recovery benchmarks under baseline conditions.

8.3.5.1.1 Winter-Run Chinook Salmon Exposure, Response, and Risk

Before the end of October, most 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 Water flow 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 is dependent on the physical attributes of the habitat and the magnitude of the change in flow. Flows during the egg incubation and initial juvenile rearing period (August to September) average approximately 8,000 cfs downstream of Keswick Dam; a stranding risk to juveniles exists when flows are reduced. The greatest risk posed by the operations proposed in the proposed action would occur when fall flows are reduced to 3,250 cfs. Although this risk is minimized through the use of ramping rates, standing is still expected to occur based on recent surveys following the same ramping rates proposed.

Managed changes in the hydrograph can result in loss of riparian habitat and instream cover and loss of natural river morphology and function, These changes can reduce accessibility to habitat that may support successful outmigration survival by providing rearing areas, refuge, or increased food availability.

8.3.5.1.2 CV Spring-Run Chinook Salmon Exposure, Response, and Risk

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 greatest risk posed by operations from October to November would occur in approximately 20 percent of years when Shasta end of September storage is expected to be less than or equal to 2.2 million acre-feet. The species response to fall flows that are are being ramped down across October and November to target 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. Flows during the CV spring-run Chinook salmon spawning period (August to October) average approximately 8,000 cfs downstream of Keswick Dam; a dewatering risk to CV spring-run Chinook salmon redds exists when flows are reduced. Redd dewatering has been monitored in the upper Sacramento River by CDFW since 2010 and survey crews have observed dewatering of redds attributed to CV spring-run Chinook in 2013 and 2014 (California Department of Fish and Wildlife 2014b; California Department of Fish and Wildlife 2015b). Similar to effects to 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 effects of juvenile CV spring-run Chinook stranding are presented in Section 8.2.3.1.1.1.2: *Winter Minimum Flows*.

With regard to CV spring-run Chinook salmon redds, the U.S. Fish and Wildlife Service (2006) flow fluctuation and redd dewatering relationship indicates that a flow reduction from an average spawning flow of about 8,000 cfs to 3,250 cfs would be expected to dewater about 33 to 42 percent of Chinook salmon redds (depending on whether the Anderson-Cottonwood Irrigation District Dam boards are out or in). Likewise, flow reductions from 8,000 cfs spawning flows to 4,000, 4,500 and 5,000 cfs would be expected to dewater about 24 to 29 percent, 18 to 22 percent and 12 to 15 percent of Chinook salmon redds, respectively. The species response to fall flows of 3,250 cfs, in the upper Sacramento River would include dewatering, which could lead to increased mortality.

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 outmigration survival by providing rearing areas, refuge, or increased food availability.

8.3.5.1.3 CCV Steelhead Exposure, Response, and Risk

During the October to November timing of operations for the Fall and Winter Refill and Redd Maintenance proposed action component, the majority of adult CCV steelhead are migrating past Red Bluff Diversion Dam (McEwan 2001). The strandings and decreased habitat risk associated with changes in operations is dependent on the physical attributes of the habitat and the magnitude of the change in flow. For the proposed action, CalSimII modeling indicates that end of September storage is less than or equal to 2.2 million acre-feet in about 20 percent of years; therefore in those years it is expected that October and November flows would be reduced to 3,250 cfs (ROC on LTO biological assessment Appendix D Table 3-2).

Similar to effects to 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. Flow fluctuations in the river reaches below Keswick Dam can strand steelhead, and are expected to persist as proposed action operations continue to pass flood control flows and target lower reservoir releases in the fall and winter to maximize storage. The effects of juvenile steelhead stranding are presented in Section 8.3.2.3, a sub-section of *Shasta Winter Operations*. A risk of steelhead redd dewatering also exists when flows are reduced following flood control releases; however, most steelhead spawning is thought to occur within tributary streams rather than the mainstem of the Upper Sacramento River.

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 outmigration survival by providing rearing areas, refuge, or increased food availability. However, increased flood control releases made necessary by earlier refill will at least partially offset these effects.

8.3.5.1.4 sDPS Green Sturgeon Exposure, Response, and Risk

sDPS 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 Fall and Winter Refill and Redd Maintenance. Adult sDPS green sturgeon migrate up river in March to early April, and spawn from April through July with the median spawning May (Poytress et al. 2015).

8.3.5.2 Rice Decomposition Smoothing

Reclamation proposes to meet a shifting demand as upstream Sacramento Valley CVP contractors and the Sacramento River Settlement Contractors synchronize their diversions to reduce demands for peak rice decomposition.

Based on the description of the proposed action component and the assessment of its effects in the biological assessment, NMFS understands that this action has the potential to build storage, which may have a beneficial effect on the subsequent cold water pool. As part of the Fall and Winter Refill and Redd Maintenance proposed action component operations described in Section 8.3.5.1, Reclamation would assess the downstream water demands of the upstream CVP contractors and the Sacramento River Settlement Contractors. Coordinated diversions in late October and early November could provide increased reliability that target flows would be met according to the Fall and Winter Refill and Redd Maintenance operations and that Reclamation would be able to build storage during this period. NMFS assumes that the minimum flows identified in the proposed action for this season would be achieved, and this action component would, therefore, provide greater certainty that Reclamation would be able to reduce releases and build storage according to the Fall and Winter Refill and Redd Maintenance action component. The effects of this action are included in the analysis of Shasta Fall Operations.

8.3.6 Conservation Measures

Conservation measures are included in the proposed action with the intent of avoiding and minimizing or compensating for CVP and SWP project effects, including take, on listed species.

8.3.6.1 Battle Creek Restoration

Reclamation will provide up to $14,000,000 in funding for ten years towards reintroduction of Winter-run Chinook Salmon to Battle Creek. Reclamation will accelerate implementation of the Battle Creek Salmon and Steelhead Restoration Project, which is intended to reestablish approximately 42 miles of prime salmon and Steelhead habitat on Battle Creek, and an additional 6 miles on its tributaries. The Battle Creek Restoration Project is a collaborative effort among several federal and state agencies and Pacific Gas & Electric Company. The partnership provides a framework for expanding Winter-Run Chinook Salmon spawning to cold water habitat not in the Sacramento River.

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 of the Battle Creek Salmon and Steelhead Restoration Project has completed construction of phase one (of two), which included removal of one fish passage barrier (a dam) and construction of NMFS-approved fish screens and ladders at the two remaining dams on North Fork Battle Creek. Phase two of the project has completed planning, and is currently in design phase. Although implementation has been significantly delayed, NMFS expects benefits to listed salmonids once completed.

While lacking specificity, NMFS notes overall beneficial effects of this accelerated action and intends to engage with Reclamation on specific approaches in order to provide credit for this action. Winter-run Chinook salmon are currently limited to a single population that spawns in an approximately 10-mile stretch of the Sacramento River, but they are being reintroduced to Battle Creek (around 200,000 juveniles were released in Battle Creek in 2018), and any returning adults from the release would benefit from the restoration efforts. NMFS notes that the proposed action is not intended to bear the responsibility of establishing viable populations, which are required for recovery of the species. However, we offer that an additional population of winter-run Chinook salmon in Battle Creek could provide strategic temperature compliance flexibility in the Sacramento River, which could alleviate constraints on Shasta operations for species protection in some conditions.

8.3.6.2 Shasta Temperature Control Device Improvements

Reclamation will coordinate with NMFS to study whether there are problems or limitations with the function of the TCD under low storage conditions, and, if necessary, identify potential actions and/or modification for improving operational efficiency of the TCD. The authority for this action is 3406(b)(6). Because this action relies on the results of a study, any benefits of this action are included in this analysis of effects in this Opinion at the framework level. If this results of this study result in improvements to the TCD, this action is expected to result in benefits for listed salmonids.

8.3.6.3 Lower Intakes near Wilkins Slough

Due to temperature requirements, Sacramento River flows at or near Wilkins Slough have decreased below the 5,000 cfs minimum navigational flow deemed by Congress. As many of the fish screens at diversions in this region were designed to operate at no less than the 5,000 cfs minimum flowrate, they may not function properly at the lower flows and, therefore, may not meet state and federal fish screening requirements during the lower flows (U.S. Bureau of Reclamation 2019c) or may cavitate and damage intake pumps. This could result in take of state and federally protected species that use this section of the river. If Reclamation determines that this proposed action component would be a cost-effective means to extend the availability of Shasta cold water pool Reclamation would provide grants to water users within this area to install new diversions and screens that would operate at lower flows. Reclamation expects that if this action were implemented, it would provide greater flexibility in managing Sacramento River flows and temperatures for both water users and wildlife, including listed salmonids (U.S. Bureau of Reclamation 2019c). However, because the proposed action does not include specificity in timing or defined actions, any benefits of this action are included in the analysis of effects in this Opinion at the framework level. Any influence Reclamation pursues to accelerate implementation of the project is expected to result in earlier benefits for listed salmonids.

Given the framework-level programmatic nature of the Lower Intakes near Wilkins Slough action component, where further commitment and collaborative planning is necessary to identify effects and quantify a level of benefits and incidental take, but where it is still possible to estimate a general level of impact qualitatively, NMFS applies the following assumptions regarding the potential species exposure, response, and risk:

- If Relamation were to implement this proposed action component, construction related to the Lower Intakes near Wilkins Slough proposed action component would be done in a manner consistent with best management practices and applicable in-water work windows, such that exposure to construction-related impacts would be minimized to the greatest extent practicable. The frequency with which species would be exposed to the construction related impacts remains uncertain as it is unknown or difficult to predict the number, timing, and location of water diversions requiring fish screen installation or remediation. NMFS assumes that a small proportion of fish may be exposed to construction-related effects such as increased turbidity, pile driving effects associated with installation of coffer dams, flow alteration around a construction site, and effects associated with handling and transport of fish isolated and rescued from behind coffer dams.
- If Relamation were to implement this proposed action component, there would be a long-term benefit associated with improving the function of existing fish screens or installing new fish screens near Wilkins Slough. This benefit would be assumed to affect juvenile fish in particular as they are most susceptible to being entrained into unscreened or poorly screened diversions. The frequency of exposure would be assumed to be high because installation or repair of fish screens would result in a semi-permanent reduction in the otherwise lethal effect of entrainment and impingement.

8.3.6.4 Spawning Gravel Injection

Reclamation proposes to create additional spawning habitat by injecting 40 to 55 tons of gravel into the Sacramento River by 2030, using the following sites: Salt Creek Gravel Injection Site, Keswick Dam Gravel Injection Site, South Shea Levee, Shea Levee, and Tobiasson Island Side Channel.

The effects of this project are included in the baseline conditions of the analysis for this Opinion. Because the ROC on LTO proposed action does not include specificity in resources, timing, or defined actions by which this project would occur, any benefits of this action besides those included in the baseline are included in this analysis of effects in this Opinion at the framework level.

Given the framework-level programmatic nature of the Spawning Gravel Injection action component, as a result of Reclamation’s continued support of this programmatic action, NMFS applies the following assumptions regarding species exposure, response, and risk:

- Expected long-term benefit associated with increasing the quantity and quality of spawning substrate in the upper Sacramento River. This benefit is expected to affect adult fish in particular as they return to spawn. The frequency of exposure is assumed to be high because completed restoration activities would result in a semi-permanent increase in spawning habitat availability.

8.3.6.5 Side Channel Habitat Restoration

Reclamation and the Sacramento River Settlement Contractors propose to create 40–60 acres of side channel habitat at approximately 10 sites in Shasta and Tehama County by 2030, including Cypress Avenue, Shea Island, Anderson River Park; South Sand Slough; Rancheria Island; Tobiasson Side Channel; and Turtle Bay.

The effects of this project are included in the baseline conditions of the analysis for this Opinion. Because the ROC on LTO proposed action does not include specificity in resources, timing, or defined actions by which this project would occur, any benefits of this action besides those included in the baseline are included in this analysis of effects in this Opinion at the framework level. Any influence Reclamation pursues to accelerate implementation of the restoration is expected to result in earlier access of beneficial habitat for listed salmonids.

Given the framework-level programmatic nature of the Side Channel Habitat Restoration action component, as a result of Reclamation’s continued support of this programmatic action, NMFS applies the following assumptions regarding species exposure, response, and risk:

- Expected long-term benefit associated with increasing the quantity and access to quality side channel rearing habitat in the upper and middle Sacramento River. This benefit is expected to affect rearing and migrating juvenile fish. The frequency of exposure is assumed to be high because completed restoration activities would result in a semi-permanent increase in rearing habitat availability.

8.3.6.6 Small Screen Program

As part of adaptive management, Reclamation and DWR propose to continue to work within existing authorities (e.g., Anadromous Fish Screen Program) to screen small diversions throughout Central Valley CVP/SWP streams and the Bay-Delta.

The beneficial effects of previous actions under this program (minimizing entrainment at a specific diversion) are included in the baseline conditions of the analysis for this Opinion. Because the ROC on LTO proposed action does not include specificity in resources, timing, or defined actions by which this program would occur, any benefits of new actions are included in this analysis of effects in this Opinion at the framework level. Any influence Reclamation pursues to accelerate implementation of this program is expected to result in earlier benefits for listed salmonids.

Given the framework-level programmatic nature of the Small Screen Program action component, where further collaborative planning is necessary to identify effects and quantify a level of benefits and incidental take, but where it is still possible to estimate a general level of impact qualitatively, NMFS applies the following assumptions regarding species exposure, response, and risk:

- That construction related to the Small Screen Program action component will be consistent with best management practices and applicable in-water work windows, which would minimize exposure to construction-related impacts to the greatest extent practicable. The frequency with which species would be exposed to the construction related impacts remains uncertain as it is unknown or difficult to predict the number, timing, and location of water diversions requiring fish screen installation or remediation. NMFS assumes that a small proportion of fish may be exposed to construction-related effects such as increased turbidity, pile driving effects associated with installation of coffer dams, flow alteration around a construction site, and effects associated with handling and transport of fish isolated and rescued from behind coffer dams.
- That there is a long-term benefit associated with improving the function of existing fish screens or installing new fish screens in the Sacramento River. This benefit is assumed to affect juvenile fish in particular as they are most susceptible to being entrained into unscreened or poorly screened diversions. The frequency of exposure is assumed to be high since installation or repair of fish screens would result in a semi-permanent reduction in the otherwise lethal effect of entrainment and impingement.

8.3.6.7 Additional Conservation Measures

During consultation, revisions to the proposed conservation measures were made that include introduction of measures to avoid and minimize or compensate for CVP and SWP project effects on species. The recent revisions have added measures related to Shasta reservoir temperature modeling, improvements to Livingston Stone National Fish Hatchery, and actions required to protect winter-run Chinook salmon during and after high mortality years.

The Temperature Modeling Platform proposed action component that Reclamation is proposing to consider as a possible Cold Water Management Tool would advance a tool that could provide a more accurate characterization of reservoir temperature conditions and contribute to more efficient use of available cold water pool, improved temperature conditions, and likely increased species protections. The Shasta Temperature Control Device Performance Evaluation is proposed to identify whether there are problems or limitations with the function of the device under low storage conditions. This evaluation could identify potential actions or modifications that would improve the operational efficiency of the device, improving cold water storage management, which would similarly lead to increased species protections if modifications were identified and implemented.

In addition, the final proposed action has added a conservation measure intended to protect the third cohort of winter-run Chinook salmon after two consecutive years of poor survival. This measure increases the likelihood that protections will be afforded to maximize the egg-to-fry survival of the year class immediately following two brood years of low egg-to-fry survival. This measure is intended to allow opportunities for actions to be implemented to protect species despite the probability of year types that may occur. While the proposed action modeling based on a historic 82-year sample set indicates a 68 percent likelihood that a year would be in Tier 1 operations, the complex dynamics of the historic hydrologic timeseries in California suggests that it is prudent to prepare for multiple years of drier-than-normal conditions, even if the summary statistics of conditions in the model period do not capture these sequential years of extended wet or extended dry periods.

Compared to the previous analysis, these revisions and additions to the conservation measures contribute to decreasing the uncertainty of the characterization of the volume of cold water pool available, and therefore the likelihood of achieving the target temperature of the determined cold water management Tier. This would be the case for the Temperature Modeling Platform, which is expected to improve the ability to predict summer operations by providing a more accurate characterization of cold water pool volume and reservoir temperature dynamics. However, the benefits of this measure are uncertain and those benefits will not be immediately realized, as the modeling is not available for implementation.

Compared to the previous analysis, the addition of the conservation measure to protect the third cohort after two years of poor survival decreases the uncertainty associated with high mortality values modeled for Tier 3 and Tier 4 years. NMFS expects that because of any actions taken in this instance, the resulting mortality value would be in the middle range of the broad range that results from the modeling (e.g., 5-77 percent in Tier 3 years), especially after two consecutive years of low survival. With this change, we consider our previous analysis of the modeled outcomes of temperature management to still apply as a conservative characterization of projected and expected operations. Based on factoring in a 32 percent background (i.e., non-temperature dependent) mortality to the modeled temperature dependent mortality for each year, the 82-year modeled dataset includes three intervals in which this type of intervention may have been warranted (1931-1934, 1976-1977, and 1991-1992). The results described in Section 2.5.2.3.3.1 Summer Cold Water Pool Management could slightly over-represent a third year of high mortality, however, the results of the modeling would not notably change the exposure of the species to the stressor of increased water temperature, or the risk based on the expected long-term proportion of years in each Tier type.

8.3.6.8 Sacramento River Settlement Contractors Recovery Program

The SRSC have carried out 41 Salmon Recovery Program actions since 2000, including 29 fish screen installation projects that avoid and minimize juvenile salmonid and sDPS green sturgeon injury and death at agricultural diversions, four fish passage projects that improve fish passage to upstream spawning habitat and reduce straying into the Colusa Basin, and eight spawning and rearing habitat improvement projects that contribute to increased production and improved growth and survival of juvenile salmonids and sDPS green sturgeon.

The continuation of these actions are expected to result in long-term benefits to winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, sDPS green sturgeon, and their designated critical habitats. The actions would also benefit fall-run Chinook salmon (which would provide benefits to southern resident killer whale by improving prey availability).

The anticipated long-term benefit associated with increasing the quantity and quality of spawning substrate in the upper Sacramento River will affect adult salmonids in particular as they return to spawn and may result in increased production over time. The frequency of exposure is assumed to be high because completed restoration activities would result in a semi-permanent increase in spawning habitat availability.

The benefits associated with increasing the quantity and access to quality side-channel and in-channel rearing habitat in the upper and middle Sacramento River will affect rearing and migrating juvenile salmonids and sDPS green sturgeon. The frequency of exposure is assumed to be high because completed restoration activities would result in a semi-permanent increase in rearing habitat availability.

The benefits associated with modifications to existing man-made structures from Keswick downstream to Verona will affect adult migrant and rearing and migrating juvenile salmonids and sDPS green sturgeon. The frequency of exposure is assumed to be high because completed restoration activities would result in a semi-permanent increase in rearing habitat availability.

8.3.6.9 **Non-Flow Projects for Salmonids**

Reclamation has proposed three additional non-flow projects during the course of the consultation that include funding support for the following projects:

1. Deer Creek Habitat/Fish Passage, $1 million

   This funding would support the Deer Creek Irrigation District Dam (DCID) Fish Passage Project. DCID is the uppermost dam on Deer Creek. DCID is a flashboard dam with a screened diversion where reduced instream flows due to irrigation demands and structural damage to the apron of the DCID dam during the 1997 flood event contributed to the difficulties of upstream migration for important native anadromous fish species. The proposed project involves constructing a nature-like fishway downstream of the dam to provide salmonids unimpeded access to over 25 miles of prime spawning habitat upstream of the DCID diversion dam, while having no adverse effect on DCID's diversion. The project includes constructing a roughened channel (rock ramp) spanning the entire width of the creek downstream of the existing dam, lowering approximately 1,400 feet of the existing diversion ditch, and replacing the off-channel fish screen and juvenile return at a lower elevation.

   Improving fish passage at this site will improve anadromous fish access to spawning, rearing and holding stream habitat upstream of the project site through the roughened rock ramp, and will improve anadromous fish passage, downstream of the project sites through fish screen and bypass pipe modifications. The project is being implemented by Trout Unlimited with funding through the federal CVPIA and from the CDFW through the Proposition 1 Watershed Restoration Grant Program. The FWS is the lead action agency. The proposed action is a high priority recovery action in the NMFS 2014 recovery plan and supports objectives of the CVPIA's Anadromous Fish Restoration Program Final Restoration Plan, complements other ongoing efforts to improve important aquatic habitats for the benefit of naturally-producing anadromous salmonids in the Central Valley, and will contribute to the recovery of Central Valley steelhead and Central Valley spring-run Chinook salmon.

2. Winter-run Chinook Salmon Reintroduction to Battle Creek, $14 million over 10 years

   Reclamation would provide up to $14,000,000 over ten years to support reintroduction of winter-run Chinook Salmon to Battle Creek through the Battle Creek Salmon and Steelhead Restoration Project and the Battle Creek Winter-run Chinook Salmon Reintroduction Plan. Reclamation would accelerate continued implementation of the Battle Creek Salmon and Steelhead Restoration Project, which is intended reestablish approximately 42 miles of prime salmon and Steelhead habitat on Battle Creek, and an additional 6 miles on its tributaries. The Battle Creek Restoration Project is a collaborative effort among several federal and state agencies and Pacific Gas & Electric Company. The partnership provides a framework for expanding Winter-Run Chinook Salmon spawning beyond its currently limited range in a single population that spawns in a short stretch of the upper Sacramento River.

As described in the *Environmental* Baseline section of the Opinion, In August 2016, CDFW released the Battle Creek Winter-run Chinook Salmon Reintroduction Plan. The U.S. Fish and Wildlife Service subsequently agreed to take on responsibility for implementing the plan, and in 2018 and 2019, approximately 400,000 juvenile winter-tun Chinook salmon were reintroduced to the North Fork of Battle Creek to jumpstart the reintroduction effort. These fish have matured and started to return as adults in summer 2019. The jumpstart effort is intended to transition into implementation of the Reintroduction Plan with Reclamation support.

Reclamation's support will go towards specific fish passage construction and reintroduction implementation activities. These include estimated costs for implementing the Project and Plan amounting to up to $7.5M in one-time construction and acquisition costs and $650,000 in annual costs for ten years. As the Reintroduction Plan continues with implementation 2030, additional funding will likely be needed to cover the annual costs. Continued implementation of the winter-run "jump-start" program and its transition to the Battle Creek Winter-run Chinook Salmon Reintroduction Plan is expected to increase the abundance and statial structure of winter-run Chinook salmon which is a high priority recovery action in the NMFS 2014 Recovery Plan for Central Valley Salmon and Steelhead.

3. Knights Landing Outfall Gates Reconstruction, $680,250

   In 2013 approximately 30 percent of the winter-run Chinook population strayed into the Colusa Basin Drain through the Knights Landing Ridge Cut and the Knights Landing Outfall Gates. In 2015 Reclamation District 108, with funding assistance from Reclamation, CDFW, and DWR, constructed a positive fish barrier at the Knights Landing Outfall Gates connection to the Sacramento River, to prevent migrating winter-run Chinook Salmon from entering into, and getting trapped in the Colusa Basin Drain. In 2016 an operational failure at the Knights Landing Outfall Gates led to the collapse of the fish barrier. Reclamation District 108 is planning to reconstruct the Knights Landing Outfall Gates fish barrier, incorporating additional operation controls and a fail-safe mechanism to prevent a repeat of the September 2016 event. Reclamation District 108 is proposing to lead implementation of the project with a 50/50 cost share of State and Federal funds. Funding will be used to reconstruct the fish barrier hoist system and electric controls. Once complete, adult winter-run Chinook salmon will not be able to enter the Colusa Basin Drain through the Knights Landing Outfall Gates.

8.3.6.10 Commitment to the Sacramento River Science Partnership

The Sacramento River Science Partnership (Partnership) will establish a general agreement, understanding, and framework for the establishment and implementation of the Mainstem Sacramento River Integrated Water and Fish Science and Monitoring Partnership.

The scope, mission, and objectives of this Partnership are expected to improve the science that is used to protect and support the recovery of winter-run Chinook salmon, CV spring-run Chinook salmon, and CCV steelhead. The Partnership is also expected to provide benefits to sDPS green sturgeon and fall-run Chinook salmon and to result in benefits to SRKW since Chinook salmon are such an important prey base.

8.3.7 Intervention Measures

In the March forecast (mid-March), if the forecasted Shasta Reservoir total storage is projected to be below 2.5 million acre-feet at the end of May (based on the 90 percent exceedance outlook), Reclamation would initiate discussions with FWS and NMFS on potential intervention measures in preparation for the low storage condition to continue into April and May. If total storage is less than 2.5 million acre-feet at the beginning of May, or if Reclamation cannot meet a daily average temperature 56°F at Clear Creek gauge, Reclamation will attempt to operate to a less than optimal temperature target and period that is determined in real-time. Reclamation proposed to develop this alternate target with technical assistance from NMFS and FWS. In addition, Reclamation proposes to implement intervention measures during these years (e.g., increasing hatchery intake, adult rescue, and juvenile trap and haul, as described below). These intervention measures would be considered by Reclamation mainly in the years identified as Tier 4 years of Summer Cold Water Pool Management, but also in Tier 3 years where water temperatures are expected to exhibit characteristics expected from a Tier 4 year. As such, the intervention measures are intended to minimize or mitigate the effects of conditions and operations associated with the bad Tier 3 years and all Tier 4 years. If the temperature management plan for a Tier 3 year indicates a higher risk of exceeding 56°F before October 1st, it will be treated as a Tier 4 year for the purposes of intervention measures and early season discussions and coordination.

8.3.7.1 Livingston Stone National Fish Hatchery Production

In a Tier 4 year, Reclamation proposes to increase production of winter-run Chinook salmon at the Livingston Stone National Fish Hatchery. As part of the increased production, Reclamation would consider New Zealand or Great Lake winter-run Chinook salmon stock for augmenting conservation hatchery stock to improve heterozygosity.

Effects of increased hatchery production will depend on complex interactions between hatchery and natural-origin fish and their environment. The short-term benefit of expanded Livingston Stone National Fish Hatchery production is that it would provide alternative (artificial) rearing and spawning habitat when the in-river environmental conditions are not suitable for egg-fry life stages. Because this proposed action component is only proposed for Tier 4 years, the intent is for it to offset, in part, the effects of Tier 4.

A potential long-term consequence of expanding numbers of hatchery fish is an increase of hatchery origin fish on in-river spawning grounds. In the development of Livingston Stone National Fish Hatchery’s HGMP considerable effort has been made to minimize any adverse genetic or ecological effects to the natural population (U.S. Fish and Wildlife Service 2016b). For example, winter-run Chinook salmon are collected and spawned throughout the duration of run timing to maintain phenotypic and genetic variability. A factorial-type spawning scheme is used to increase the effective population size of hatchery-produced winter-run Chinook salmon. Phenotypic and genetic broodstock selection criteria are used to ensure that the potential for genetic bottlenecks do not occur in the hatchery. Further, limits have been established for the collection of natural-origin winter-run Chinook salmon broodstock; the annual limit for broodstock collection is 60 females and up to 120 males, totaling up to 180 adult natural-origin winter-run Chinook salmon. These limits guard against removing too many fish from the naturally-spawning population and increase the effective population size of the hatchery component of the population.

In fact, increasing production at Livingston Stone National Fish Hatchery is already considered as part of the hatchery’s HGMP, where during emergencies, such as the extreme drought of 2014 and 2015, production of winter-run Chinook salmon may be increased above the standard production levels to partially mitigate for extremely poor environmental conditions. The temporary expansion of winter-run Chinook salmon propagation activities in 2014 and 2015 was based on the anticipation of temperatures unfavorable for successful natural spawning in the Sacramento River. During those years when environmental conditions result in the need for increased hatchery production (limited to a maximum of 400 adult winter-run Chinook salmon for use as broodstock), broodstock collection targets are determined collaboratively by FWS, NMFS, and CDFW. Factors such as expected adult escapement, expected environmental conditions, expected juvenile survival, and the number of tagged juveniles available for fishery assessments will be considered when determining whether program expansion is warranted (U.S. Fish and Wildlife Service 2016b).

Also, as described in the Section 2.4 Environmental Baseline section of this Opinion and in the ROC on LTO biological assessment Appendix C, the FWS has been engaged in efforts regarding Livingston Stone National Fish Hatchery. During the drought in 2014 and 2015, and at the request of NMFS and CDFW, Livingston Stone National Fish Hatchery increased production of winter-run Chinook salmon to compensate for expected high temperature-dependent mortality in the Sacramento River and re-instated the captive broodstock program. Reclamation also 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 a just few occasions. Subsequently, Reclamation has funded a small permanent chiller to ensure temperatures for egg incubation only. Reclamation also supports FWS efforts for coded-wire tagging, acoustic tagging, and associated monitoring of national fish hatchery-produced winter-run Chinook salmon under long-term operational funding agreements that have a long history of renewal.

NMFS anticipates that additional improvements will be necessary to support the proposed intervention measure, including securing an emergency or alternate water supply when Shasta and Keswick reservoirs reach elevations below the current penstock, acquiring water chillers to ensure that adequate water temperatures are provided during critical winter-run

Chinook salmon life stages, acquiring more physical space to adequately rear increased production to help the population withstand the drought and to successfully operate the captive broodstock program, making modifications or improvements to Keswick Dam Fish Trap, making improvements to the water treatment facility, and possibly making modifications/improvements to the Anderson-Cottonwood Irrigation District fish trap. These improvements are described in detail in ROC on LTO biological assessment Appendix C and generally summarized below:

- Current ideas for improving water supply include: (1) replacing and upgrading valves, controllers, and alarms to ensure the water supply is more secure and staff are better able to respond to water alarms; and (2) connecting Penstock 5 (which is lower than the other penstocks) to the hatchery water system to allow greater flexibility to provide more cold water during low lake levels and during penstock maintenance outages. Replacing and upgrading valves, controllers, and alarms would improve biosecurity and efficiency at the hatchery under all conditions.
- Installing chillers at critical times during drought conditions for adult holding and juvenile rearing is essential to ensure that the increased demand can be met during drought years.
- In 2016, a multi-agency work team concluded Livingston Stone National Fish Hatchery would need to expand by 8 to 10 circular tanks to raise an additional 350,000 fish if the hatchery were to engage in the same drought operations they did in the recent drought. Increasing the capacity of Livingston Stone National Fish Hatchery would require expanding to the west side of the hatchery road, additional piping to that side of the property, and additional water.
- An investigation to to evaluate improvements to the fish trap and elevator to reduce the likelihood of injuring or killing fish during fish transfer. FWS is planning to discuss the potential need for improvements with Reclamation, and if improvements are necessary, is confident that the agencies can identify the funds necessary to implement the improvements.
- The FWS has recently begun to discuss the potential need for a drum screen to remove solids in the hatchery's effluent. The drum screen could allow the FWS more flexibility in the use of medicated feed to prevent and treat disease.

With little description of this action component, how it may differ from the existing HGMP or how it may affect the species, there is insufficient information available to assess the effects, and how those may differ from effects analyzed in the HGMP, which is part of the baseline. In order to provide enough certainty regarding how and when the proposed action component would be implemented, and to assess its effects, the expanded production at Livingston Stone National Fish Hatchery will need to be developed further. Generally, a commitment to assess and eventually incorporate the expanded production at Livingston Stone National Fish Hatchery would be expected to have beneficial effects decreasing the potential negative effects of environmental conditions and water operations during a Tier 4 year, but additional facility improvements or expanded use of the captive broodstock program may be necessary to accommodate this Tier 4 action. NMFS is also uncertain of the viability of using of New Zealand or Great Lakes winter-run Chinook salmon stock for augmenting conservation hatchery stock to improve heterozygosity, and there are potential negative consequences to the species of introducing an outside stock. Additional science is necessary to begin consideration of those stocks. Uncertainty regarding the effects of the proposed action component could be addressed, and the mechanism for incorporating the proposed action component in to operations would be described and understood through implementation of this Collaborative Planning Action.

8.3.7.2 Adult Rescues

Reclamation proposes to trap and haul adult salmonids and sturgeon from Yolo and Sutter bypasses during droughts and after periods of bypass flooding, when flows from the bypasses are most likely to attract upstream migrating adults, and move them up the Sacramento River to spawning grounds. This trap and haul is in addition to weir fish passage projects that are part of the proposed action elsewhere. This could improve survival of the adults, leading to increased juvenile production in the following year and more flexibility with salvage. Because the ROC on LTO proposed action does not include details on these rescue actions (e.g., process for identifying the need, process for rescue and return, evaluation of return success or definition of performance metrics, definition of reporting tasks), NMFS considers this a programmatic action. Effects are considered but exemption for take associated with this action is not provided in this Opinion.

8.3.7.3 Juvenile Trap and Haul

If Reclamation projects Tier 4 operations for an upcoming summer (i.e., less than 2.5 million acre-feet of Shasta storage at the beginning of May), the proposed action includes that Reclamation will propose implementation of a downstream trap and haul strategy for the capture and transport of juvenile Chinook salmon and steelhead in the Sacramento River watershed. This is proposed for drought years when low flows and resulting high water temperatures are unsuitable for volitional downstream salmonid migration and survival. Reclamation proposes to place temporary juvenile collection weirs at key feasible locations downstream of spawning areas in the Sacramento River. Reclamation would transport collected fish to a safe release location or locations in the Delta upstream of Chipps Island. Juvenile trap and haul activities would occur from December 1 through May 31, consistent with the migration period for juvenile Chinook salmon and steelhead (National Marine Fisheries Service 2014b), depending on hydrologic conditions. In the event of high river flows or potential flooding, the fish weirs would be removed. The benefits of this component is uncertain, even for years of extremely low storage. Because the ROC on LTO proposed action does not include details on these trap and haul actions (e.g., process for identifying the need, process for trapping and return, evaluation of return success or definition of performance metrics, definition of reporting tasks), NMFS considers this a programmatic action. Exemption for take associated with this action is not provided in this Opinion.

8.3.8 Division Effects Summary

The following tables summarize the project-related stressors in the Upper Sacramento/Shasta Division by species, life-stage, and project component. The 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.

8.3.8.1 Sacramento River Winter-Run Chinook Salmon

Sacramento River winter-run Chinook salmon will be effected by the proposed action at the life-stages of eggs-to-fry, juvenile, and adults (Table 25, Table 26, and Table 27).

Table 25. Summary of proposed action-related effects on Sacramento River winter-run Chinook salmon eggs-to-fry life stage in the upper Sacramento River/Shasta Division.

Action Component	Individual Response and Rationale of Effect	Severity or Level of Benefit	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness
Shasta Cold Water Pool Management -Tier 1	Mean temperature dependent mortality of 5% (Anderson) and 6% (Martin)	Lethal	Large	Medium	High	High	Loss of 5 - 6% eggs/fry exposed
Shasta Cold Water Pool Management -Tier 2	Mean temperature dependent mortality of 12% (Anderson) and 15% (Martin)	Lethal	Large	Low to Medium	High	High	Loss of 12 - 15% eggs/fry exposed
Shasta Cold Water Pool Management -Tier 3	Mean temperature dependent mortality of 28% (Anderson) and 34% (Martin)	Lethal	Large	Low	High	High	Loss of 28 - 34% eggs/fry exposed
Shasta Cold Water Pool Management -Tier 4	Mean temperature dependent mortality of 79% (Anderson) and 81% (Martin)	Lethal	Large	Low	High	High	Loss of 79 - 81% eggs/fry exposed
Spring Pulse Flow	Temperatures higher than 53.5°F would result in egg/fry mortality	Lethal	Small - Medium	Medium	Medium - High	Medium	Loss of <2 - 6% eggs/fry exposed
Delta Smelt Summer-Fall Habitat	Temperatures higher than 53.5°F would result in egg/fry mortality	Lethal	Medium - Large	Low	High	High	Decreased survival of eggs/fry exposed to temperatures above 53.5°F
Temperature Modeling Platform	Improved modeling should help minimize temperature dependent mortality	Beneficial: High	Large	Medium	High	High	Increased survival of eggs/fry not exposed to temperatures above 53.5°F
Actions for Year After Two Low Survival Years	Temperatures higher than 53.5°F would result in egg/fry mortality	Beneficial: High	Large	Low	High	High	Increased survival of eggs/fry not exposed to temperatures above 53.5°F
Drought and Dry Year Actions	Temperatures higher than 53.5°F would result in egg/fry mortality	Beneficial: High	Large	Low	High	High	Increased survival of eggs/fry not exposed to temperatures above 53.5°F
Temperature Management Plan Using Conservative Forecasts	Temperatures higher than 53.5°F would result in egg/fry mortality	Beneficial: High	Large	High	High	High	Increased survival of eggs/fry not exposed to temperatures above 53.5°F

Action Component	Individual Response and Rationale of Effect	Severity or Level of Benefit	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness
Winter Minimum flows	preserve cold water pool	Beneficial: High	Medium	Low	Medium	High	Increased survival of eggs/fry not exposed to temperatures above 53.5°F
Fall and Winter Refill and Redd Maintenance	preserve cold water pool	Beneficial: High	Medium	Low	Medium	High	Increased survival of eggs/fry not exposed to temperatures above 53.5°F

Table 26. Summary of proposed action-related effects on Sacramento River winter-run Chinook salmon juvenile life stage in the upper Sacramento River/Shasta Division.

Action Component	Stressor/ Factor	Individual Response and Rationale of Effect	Severity or Level of Benefit	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness
Small Screen Program	Entrainment/ impingement	Reduced potential for injury or death at water diversions	Beneficial: High	Medium	High (Operations)	High	Low	Increased survival of fish not entrained or impinged
Wilkins Slough intakes	Entrainment/ impingement, water flow	Reduced potential for injury or death at water diversions	Beneficial: High	Medium	High (Yearly Operations)	Medium - High	Low	Increased survival of fish not entrained or impinged
Winter Minimum flows	Water flow	Reduced flow reduces habitat area, increased competition and predation	Sublethal	Medium	Low	Medium	Low	Reduced survival of fish exposed
Fall and Winter Refill and Redd Maintenance	Water flow	Decreased habitat carrying capacity, increased competition and predation	Sublethal	Medium	Low	Medium	Low	Reduced survival of fish exposed

Action Component	Stressor/ Factor	Individual Response and Rationale of Effect	Severity or Level of Benefit	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness
Rice Decomposition smoothing	Water flow	More reliable fall flows decreasing the potential for juvenile stranding	Benefit: Low	Medium	Low	Low	Low	increased survival due to reduced isolation and stranding; and increased storage of cold water pool
Wilkins Slough intakes	Passage impediments/barriers, water flow	construction during in-water work window and include minimization measures to limit potential effects to species.	Lethal	Medium	Uncertain	Uncertain due to uncertain frequency	Low	Reduced survival of juveniles exposed
Juvenile Trap and Haul (Tier 4 intervention)	Capture, handling, release	Increased stress and mortality related to capture and handling.	Mitigation (Lethal)	Uncertain	Low	Uncertain, High	Low	Increased survival of fish collected compared to fish not collected
Side-Channel habitat	Water flow	Increased habitat quality and quantity	Uncertain Beneficial: Low	Uncertain, but at least low	High	Uncertain, but at least low	Low	Increased growth continuing from the baseline
Small Screen Program (Spawning/rearing habitat restoration)	Passage impediments/barriers, water flow	Assumed construction effects related to installation of fish screens include: changes in flow, stranding (installation of coffer dams), and handling.	Lethal	Medium	Uncertain	Uncertain	Low	Reduced survival of juveniles exposed
Fall Delta smelt habitat	Habitat management	Management of salinity mixing zone may improve food resources for salmonids in Delta	Beneficial: Low	Small	Medium	Low	Uncertain	Uncertain benefits

Table 27. Summary of proposed action-related effects on Sacramento River winter-run Chinook salmon adult life stage in the upper Sacramento River/Shasta Division.

Action Component	Stressor/Factor	Individual Response and Rationale of Effect	Severity or Level of Benefit	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness
Livingston Stone National Fish Hatchery Production (tier 4 intervention)	Increased hatchery production	Intervention measure to address a lack of suitable spawning and rearing habitat during periods of drought	Beneficial:High	High (Uncertain)	Low	High	High	Short-term increased reproductive success, but also reduced viability due to increased hatchery influence
Wilkins Slough intakes (Cold water pool management)	Entrainment/ Impingement at water diversions, Water flow	Reduced potential for entrainment/ impingement at diversions	Beneficial: High	Low	High	Medium - High	Low	Increased survival for adult salmon exposed
Spring Pulse Flow	Water flow, Passage Impediments/Barriers	Elevated flows may facilitate swimming past barriers, or they may serve as a cue for migration	Beneficial: Low	Large	Medium	Medium	Medium	Improved survival of migrating adult fish and improved survival of eggs prior to spawning
Spring Mgmt. of Spawning Locations	Water Temperature, Spawning Habitat Availability	Proposed research and management to determine the effect of water temperature on the timing and location of spawning. Warmer temperatures may delay spawning	Low (Uncertain)	Large	High (Uncertain)	Medium (Uncertain)	Low	Improved survival of migrating adult fish and improved survival of eggs prior to spawning
Spawning Gravel Injection (Spawning/rearing habitat restoration)	Spawning Habitat Availability, Loss of Riparian Habitat and Instream Cover, Physical Habitat Alteration	Increased habitat quality and quantity	Beneficial: Low	Uncertain, but at least low	High	Uncertain, but at least low	Low	Increased reproductive success continuing from the baseline

Action Component	Stressor/Factor	Individual Response and Rationale of Effect	Severity or Level of Benefit	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness
Small Screen Program (Spawning/rearing habitat restoration)	Passage Impediments/Barriers, Water flow	Assumed construction effects related to installation of fish screens include: changes in flow, stranding (installation of coffer dams), and handling.	Lethal	Medium	Uncertain	Uncertain	Low	Reduced survival probability
Adult rescue (intervention)	Passage Impediments/ Barriers, Entrainment/ Impingement at water diversions	Increased stress and mortality related to capture and handling. Minimization measure intended to increase relative survival of adult salmonids entrained in water diversions	Mitigation (Lethal)	Uncertain	Uncertain	Uncertain	Low	Improved survival of migrating adult fish and improved survival of eggs prior to spawning

8.3.8.2 Central Valley Spring-Run Chinook Salmon

Sacramento River spring-run Chinook salmon eggs-to-fry, juvenile, and adults will be affected by the proposed action (Table 28, Table 29, and Table 30).

Table 28. Summary of upper Sacramento River/Shasta Division operation-related effects on egg-to-fry life stage of Central Valley spring-run Chinook salmon.

Action Component	Stressor/ Factor	Individual Response and Rationale of Effect	Severity or Level of Benefit	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness
Shasta Cold Water Pool Management - Tier 1	Water Temperature	Temperatures higher than 53.5°F would result in egg/fry mortality	Lethal	Large	Medium	High	High	Mortality of some eggs/fry exposed to temperatures above 53.5°F
Shasta Cold Water Pool Management - Tiers 2,3, and 4	Water Temperature	Temperatures higher than 53.5°F would result in egg/fry mortality	Lethal	Large	Low	High	High	Mortality of some eggs/fry exposed to temperatures above 53.5°F
Temperature Management Plan Using Conservative Forecasts	Water Temperature	Temperatures higher than 53.5°F would result in egg/fry mortality	Beneficial: Low	Large	High	Medium	High	Increased survival of eggs/fry not exposed to temperatures above 53.5°F
Drought and Dry Year Actions	Water Temperature	Actions to mitigate for temperatures higher than 53.5°F	Beneficial: Low	Large	Low	Medium	High	Increased survival of eggs/fry not exposed to temperatures above 53.5°F
Delta Smelt Summer-Fall Habitat	Water Temperature	Temperatures higher than 53.5°F would result in egg/fry mortality	Lethal	Large	Low	High	High	Mortality of some eggs/fry exposed to temperatures above 53.5°F
Temperature Modeling Platform	Water Temperature	Temperatures higher than 53.5°F would result in egg/fry mortality	Beneficial: Low	Large	Medium	Medium	High	Increased survival of eggs/fry not exposed to temperatures above 53.5°F

Action Component	Stressor/ Factor	Individual Response and Rationale of Effect	Severity or Level of Benefit	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness
Water temperature management: Fall	Water Temperature	Temperatures higher than 53.5°F would result in egg/fry mortality	Lethal and Sublethal	Medium	Medium	High-Medium	High	Mortality of some eggs/fry exposed to temperatures above 53.5°F
Minimum instream base flows	Water flow	Base flow reductions in Critical water year types, and/or after the fall water temperature management period will dewater redds	Sublethal	Medium	Low	Low	Medium	Mortality of eggs/fry in dewatered redds

8.3.8.3 CCV Steelhead

Below the components of the proposed action in the Upper Sacramento/Shasta Division are summarized by their effects on various life stages of CCV steelhead. The CCV steelhead life stages of eggs-to-fry, juvenile, and adults will be affected by the proposed action (Table 29, Table 30, and Table 31).

Table 29. Summary of Upper Sacramento/Shasta Division operation-related effects on egg-to-fry life stage of California Central Valley steelhead.

Action Component	Stressor	Individual Response and Rationale of Effect	Severity of Stressor/Level of Benefit	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness
Winter Minimum flows	Water flow	Possible dewatering of redds	Lethal	Small	Low	High	Medium	Reduced survival of eggs in dewatered redds

Table 30. Summary of Upper Sacramento/Shasta Division operation-related effects on juvenile California Central Valley steelhead.

Action Component	Stressor	Individual Response and Rationale of Effect	Severity of Stressor/Level of Benefit	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness
Fall and Winter Minimum flows, Refill and Redd Maintenance	Water flow	Decreased flows may result in habitat reduction from decreased floodplain inundation and side-channel habitat isolated	Lethal	Low	Low	Low	Low:	Reduced growth due to less available rearing habitat
Small Screen Program (Spawning/rearing habitat restoration)	Entrainment/ Impingement at water diversions	assumed to comply with fish screening guidance	Beneficial: High	Uncertain	High	High, uncertain	Low	Increased survival of fish not subject to the stressor
Drought and Dry Year Actions	Water Temperature, Water Flow	expected to benefit rearing juveniles	Beneficial: Low	Medium	Low	Medium	High	Increased survival probability
Temperature Management Plan Using Conservative Forecasts	Water Temperature	Temperatures below 61°F may increase survival	Beneficial: Low	Large	High	Medium	High	Increased survival at temperatures below 61°F
Shasta Cold Water Pool Management - Tier 1	Water Temperature	Temperatures higher than 61°F may result in stress	Sub-lethal	Large	Medium	High	High	Reduced reduced growth rate and survival above 61°F

Action Component	Stressor	Individual Response and Rationale of Effect	Severity of Stressor/Level of Benefit	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness
Shasta Cold Water Pool Management - Tiers 2,3, and 4	Water Temperature	Temperatures higher than 61°F may result in stress	Sub-lethal	Large	Low	High	High	Reduced reduced growth rate and survival above 61°F
Delta Smelt Summer-Fall Habitat	Water Temperature	Temperatures in excess of 61°F will lead to stress	Sublethal	Low	Low	Low	Low	decreased survival probability
Juvenile Trap and Haul (tier 4 intervention)	Water Temperatures	measure intended to increase survival during Tier 4 water temperature operations	Sub-Lethal	Uncertain	Low	Low	Low	Increased growth rate, Increased survival probability
Wilkins Slough intakes (Cold water pool mgmt.)	Entrainment/Impingement at water diversions	assumed to comply with fish screening guidance.	Beneficial: Low	Small	High (Permanent)	Low	Low	Increased survival probability
Side-Channel habitat	Spawning/rearing habitat restoration	Increased habitat quality and quantity	Beneficial: Low	Uncertain	High	Low	Low	Increased growth rate
Spawning Gravel Injection	Spawning/rearing habitat restoration	Increased habitat quality and quantity	Beneficial	Uncertain	High	Medium	Medium to High	Increased growth rate, Increased lifetime reproductive success
Battle Creek Restoration	Spawning/rearing habitat restoration	Increased habitat quantity and quality	Sub-lethal	Medium	High	High	High	Increased growth rate, Increased lifetime reproductive success

Table 31. Summary of Upper Sacramento/Shasta Division operation-related effects on adult California Central Valley steelhead.

Action Component	Stressor	Individual Response and Rationale of Effect	Severity of Stressor/Level of Benefit	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness
Fall and Winter Refill and Redd Maintenance	Water flow	Decreased flows resulting in reduced spawning habitat	Sublethal	Medium	Low	Low	Medium	Reduced productivity
Winter Minimum flows	Water flow	Increased habitat carrying capacity in some reaches	Beneficial: low	Small	Low	Low	Low	Increased spawning success, potentially decreased productivity
Shasta Cold Water Pool Management - Tiers 2,3, and 4	Water Temperature	Temperatures higher than 68°F would cause stress	Sub-lethal	Medium	Low	Low	Medium	decreased survival, reduced reproductive success
Wilkins Slough intakes Construction or installation of fish screens on water diversions	Passage Impediments/ Barriers, Water flow	assumes construction would occur during an in-water work window and minimization measures limit effects	Sub-lethal	Low	Uncertain (Construction)	Low	Low: (uncertain)	Decreased survival probability
Adult rescue (tier 4 intervention)	Passage Impediments/ Barriers, Entrainment/ Impingement	increase survival of fiah rescued.	Beneficial: Low	Small	Low	Low	Low	Increased reproductive success, Increased survival probability

Action Component	**Stressor**	**Individual Response and Rationale of Effect**	**Severity of Stressor/Level of Benefit**	**Proportion of Population Exposed**	**Frequency of Exposure**	**Magnitude of Effect**	**Weight of Evidence**	**Probable Change in Fitness**
Side-Channel habitat	Spawning/rearing habitat restoration	Increased habitat quantity and quality.	Beneficial: Low	Uncertain	High (Permanent)	Low	Low	Increased growth rate. Increased lifetime reproductive success
Spawning Gravel Injection	Spawning/rearing habitat restoration	Increased habitat quantity and quality	Beneficial	Uncertain	High (Permanent)	Medium	Medium to High	Increased growth rate, Increased lifetime reproductive success
Battle Creek Restoration	Spawning/rearing habitat restoration	Increased habitat quantity and quality	Sub-lethal	Medium	High	High	High	Increased growth rate, Increased lifetime reproductive success

8.3.8.4 sDPS Green Sturgeon

Below the components of the proposed action in the Upper Sacramento/Shasta Division are summarized by their effects on various life stages of sDPS green sturgeon. The sDPS green sturgeon eggs-to-fry, juvenile, and adults will be affected by the proposed action (Table 32, Table 33, and Table 34).

Table 32. Summary of Upper Sacramento/Shasta Division operation-related effects on egg/larvae Southern DPS green sturgeon.

Action Component	Stressor	Individual Response and Rationale of Effect	Severity of Stressor/Level of Benefit	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness
Drafting of Temperature Management Plan Using Conservative Forecasts	Water temperature	Expected to reduce the frequency of temperatures higher than 53.5°F to provide an indirect benefit to spawning sDPS green sturgeon	Beneficial: Low	Large	High	Medium	High	Increased reproductive success; increased survival probability
Delta Smelt Summer-Fall Habitat	Water temperature	Temperature ranges from temps associated with abnormal development of eggs and larvae (Sublethal) to decrease in egg survival (Lethal) in lab studies.	Sublethal	Large	Low	Medium	Low	Decreased reproductive success; decreased survival probability
Drought and Dry Year Actions	Water temperature	Actions are expected to benefit the sDPS green sturgeon	Beneficial: Low	Large	Low	Medium	High	Increased reproductive success; increased survival probability
Temperature Modeling Platform	Water temperature	Reduce the uncertainty related to temperature forecasting which could minimize temperature dependent mortality for winter-run Chinook salmon and to a lesser extent the other ESUs or DPSs spawning in the Sacramento River.	Beneficial: Low	Large	Medium	Medium	High	Increased reproductive success; increased survival probability
Shasta Cold Water Pool Management	Water temperature	temperature ranges from temps associated with abnormal development of eggs and larvae (Sublethal) to decrease in egg survival (Lethal) in lab studies.	Sublethal	Medium	Medium	Medium	Medium	Reduced reproductive success

Table 33. Summary of Upper Sacramento/Shasta Division operation-related effects on juvenile Southern DPS green sturgeon.

Action Component	Stressor	Individual Response and Rationale of Effect	Severity of Stressor/Level of Benefit	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness
Spawning Gravel Injection (Spawning/rearing habitat restoration)	Spawning Habitat Availability, Loss of Riparian Habitat and Instream Cover, Physical Habitat Alteration	Increased habitat quality and quantity. Programmatic action component, no description of timing, location or extent of effects.	Beneficial: Low (Uncertain)	Low	High	Low	Low	Increased reproductive success and survival probability
Small Screen Program (Spawning/rearing habitat restoration)	Construction or installation of fish screens on water diversions. Passage Impediments/Barriers, Water flow, Loss of Riparian Habitat and Instream Cover	Framework programmatic action component. Construction activities are not described but assumed effects related to installation of fish screens include: changes in flow, stranding (installation of coffer dams), and handling.	Sublethal	Low	Low	Low	Low	Reduced reproductive success, Reduced survival probability
Small Screen Program (Spawning/rearing habitat restoration)	Operation of new or repaired fish screens on water diversions. Entrainment/Impingement at water diversions	Construction activities are not described but operation is assumed to comply with NMFS and CDFW fish screening guidance.	Beneficial: Low	Uncertain	High	Low	Low	Increased survival probability (NMFS/CDFW fish screening criteria 5% loss)
Wilkins Slough intakes (Cold water pool mgmt.)	Entrainment/Impingement at water diversions, Passage Impediments/Barriers, Water flow,	operation is assumed to comply with NMFS and CDFW fish screening guidance.	Beneficial: Low	Small	Low	Low	Low	Increased survival probability

Action Component	Stressor	Individual Response and Rationale of Effect	Severity of Stressor/Level of Benefit	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness
Side-Channel habitat	Spawning/rearing habitat restoration	Increased habitat quality and quantity. Framework programmatic action component. No description of timing, location or extent of effects	Beneficial: Low	Uncertain	High	Low	Low	Increased growth rate
Juvenile Trap and Haul (tier 4 intervention)	Monitoring, Maintenance, Research Studies, etc. (minimization for Water Temperatures)	green sturgeon may be collected and returned to the river or relocated	Sublethal	Uncertain	Low	Low	Low	Reduced survival probability
Fall and Winter Refill and Redd Maintenance	Water flow	Decreased flows may reduce access to channel margin and side channel rearing habitats	Minor	Uncertain	Uncertain	Low	Low	Reduced growth rate and survival probability
Winter Minimum flows	Water flow	Decreased flows may reduce access to channel margin and side channel rearing habitats	Minor	Uncertain	Uncertain	Low	Low	Reduced growth rate and survival probability

Table 34. Summary of Upper Sacramento/Shasta Division operation-related effects on adult Southern DPS green sturgeon.

Action Component	Stressor	Individual Response and Rationale of Effect	Severity of Stressor/Level of Benefit	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness
Drafting of Temperature Management Plan Using Conservative Forecasts	Water Temperature	Expected to reduce the frequency of temperatures higher than 53.5°F during the winter-run Chinook salmon spawning and incubation period. It is expected to provide an indirect benefit to the sDPS green sturgeon that spawn in the Sacramento River as well.	Beneficial: Low	Large	High	Medium	High	Increased reproductive success; increased survival probability
Delta Smelt Summer-Fall Habitat	Water Temperature	PA temperature ranges from temps associated with abnormal development of eggs and larvae (Sublethal) to decrease in egg survival (Lethal) in lab studies.	Sublethal	Large	Low	Medium	Low	Decreased reproductive success; decreased survival probability
Drought and Dry Year Actions	Water Temperature	Drought and Dry Year Actions have been identified for winter-run Chinook salmon as a way to mitigate for temperatures higher than 53.5°F which result in reduced egg survival. These actions are expected to benefit the sDPS green sturgeon in the Sacramento River to a lesser degree.	Beneficial: Low	Large	Low	Medium	High	Increased reproductive success; increased survival probability

Action Component	Stressor	Individual Response and Rationale of Effect	Severity of Stressor/Level of Benefit	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness
Temperature Modeling Platform	Water Temperature	Reduce the uncertainty related to temperature forecasting which could minimize temperature dependent mortality	Beneficial: Low	Large	Medium	Medium	High	Increased reproductive success; increased survival probability
Spring Pulse Flow	Altered Flow, Passage Impediments/ Barriers to Migration	Increased flows may facilitate swimming past barriers, or they may merely serve as a cue for migration. High flows are also correlated with lower temperatures that benefit females migrating upriver by ensuring that eggs are not damaged before spawning.	Beneficial: Medium	Large	Medium	Medium	Medium	Improved reproductive success
Spring Mgmt. of Spawning Locations	Water temperature	Lower temperatures may benefit pre-spawn females by ensuring that eggs are not damaged and normal embryo development occurs after spawning	Beneficial: Medium	Large	Uncertain	Medium	Low	Improved reproductive success
Tier 4 (Shasta Cold Water Pool Mgmt.)	Water temperature	temperature ranges from temps associated with abnormal development of eggs and larvae (Sublethal) to decrease in egg survival (Lethal) in lab studies.	Sublethal, Lethal	Large	Low	Medium, High	Medium	Reduced reproductive success, Reduced survival probability
Spawning Gravel Injection (Spawning/rearing habitat restoration)	Spawning Habitat Availability, Loss of Riparian Habitat and Instream Cover, Physical Habitat Alteration	Increased habitat quality and quantity. Programmatic action component, no description of timing, location or extent of effects.	Beneficial: Low (Uncertain)	Low	High	Low	Low	Increased reproductive success and survival probability

Action Component	Stressor	Individual Response and Rationale of Effect	Severity of Stressor/Level of Benefit	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness
Small Screen Program (Spawning/rearing habitat restoration)	Construction or installation of fish screens on water diversions. Passage Impediments/Barriers, Water flow, Loss of Riparian Habitat and Instream Cover	assumed construction effects related to installation of fish screens include: changes in flow, stranding (installation of coffer dams), and handling.	Sublethal	Low	Low	Low	Low	Reduced reproductive success, Reduced survival probability
Small Screen Program (Spawning/rearing habitat restoration)	Operation of new or repaired fish screens on water diversions. Entrainment/Impingement at water diversions	assumed to comply fish screening guidance.	Beneficial: Low	Uncertain	High	Low	Low	Increased survival probability
Shasta Cold Water Pool Management	Water temperature	temperature ranges from temps associated with abnormal development of eggs and larvae (Sublethal) to decrease in egg survival (Lethal) in lab studies.	Sublethal	Medium	Low	Low	Medium	Reduced reproductive success
Wilkins Slough intakes (Cold water pool mgmt.)	Passage Impediments/Barriers, Water flow	assume construction would occur during an in-water work window and include minimization measures to limit potential effects to species.	Sublethal	Small	Uncertain	Low	Low	Reduced survival probability
Side-Channel habitat	Spawning/rearing habitat restoration	Increased habitat quality and quantity.	Beneficial: Low	Uncertain	High	Low	Low	Increased growth rate
Adult rescue (tier 4 intervention)	Passage Impediments/Barriers, Entrainment/Impingement at water diversions	Increased stress and mortality related to capture and handling	Beneficial: Low	Uncertain	Uncertain	Low	Low	Increased reproductive success, Increased survival probability

8.4 Trinity River Division

NMFS deconstructed the proposed action to identify the project components (Figure 56) that would create stressors that may affect listed species (Table 35). The exposure, risk, and response of each species to the project-related stressors are then analyzed in the following sections for each proposed action component.

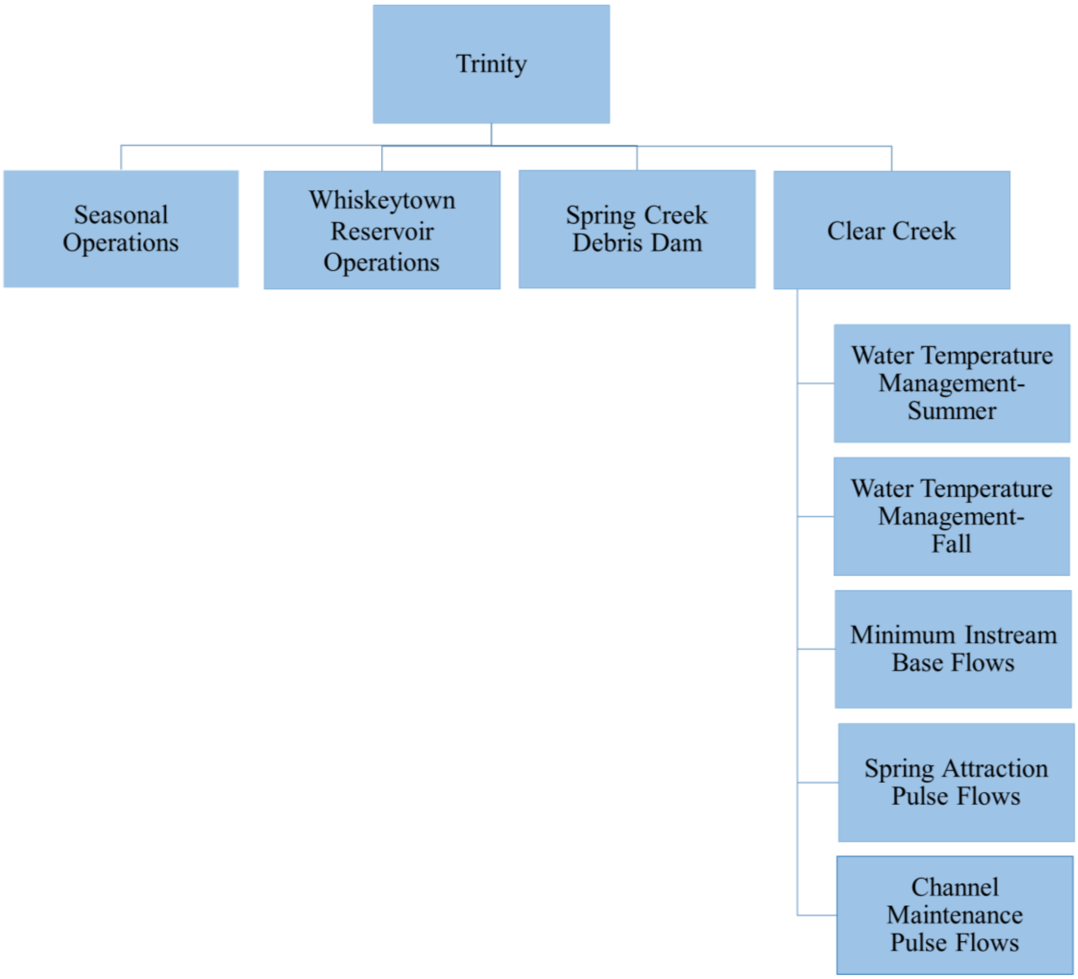


Figure 56. Deconstructed proposed actions in the Trinity Division.

Table 35. Stressors created by the proposed action components in the Trinity River Division.

Project Component	Water Temperature	Water Quality	Water Flow
Spring Creek Debris Dam	X	X	X
Water Temperature Management -Summer	X	-	X
Water Temperature Management –Fall	X	-	-

Project Component	Water Temperature	Water Quality	Water Flow
Minimum Instream Base Flows	X	-	X
Spring Attraction Pulse Flows	X	X	X
Channel Maintenance Pulse Flows	-	X	X

An "X" indicates that the action component affects a stressor category; the response could be negative or positive.

8.4.1 Temporal and Spatial Occurrence of Listed Salmonids in Clear Creek

Clear Creek supports CV spring-run Chinook salmon and CCV steelhead.

8.4.1.1 Central Valley Spring-run Chinook Salmon

Adult CV spring-run Chinook salmon migrate into Clear Creek from April to August, and peak passage occurs in May and June (Clear Creek Technical Team 2018; Giovannetti and Brown 2013). 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.

CV spring-run Chinook salmon migrate into Clear Creek several months before fall-run Chinook salmon migration begins. A large portion of the CV spring-run Chinook salmon typically moves to the upstream 10 miles of the creek, to hold in the colder water of the canyon. Before the arrival of fall run Chinook salmon, and just prior to the onset of CV spring-run Chinook salmon spawning, the FWS installs and operates a temporary weir each year to physically separate the two runs during spawning to minimize hybridization and redd superimposition. The segregation weir is placed at river mile 7.5 or 8.2 in late August and left in place until early November after the peak of fall-run Chinook salmon spawning when there is no chance of hybridization, and risk of redd superimposition is very low. The weir location and timing were determined to protect the most CV spring-run Chinook salmon, while minimizing effects to other salmonids (Giovannetti and Brown 2013). Any CV spring-run Chinook salmon downstream of the weir are likely to hybridize with fall-run Chinook salmon, or redds would be subject to redd superimposition.

Spawning occurs from early September through October, and peaks in late-September (Giovannetti and Brown 2013). Egg incubation occurs from September to early February based on redd timing. Based on juvenile passage indices from the FWS rotary screw trap (river mile 8.4), fry emergence begins in early November, peak passage occurs from mid-November through January, and 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). While the majority of juvenile CV spring-run Chinook salmon outmigrate 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).

8.4.1.2 California Central Valley Steelhead

Adult CCV steelhead migration into Clear Creek begins in late-August and continues through April. 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 six 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 beginning in mid-January, and 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 FWS have also documented the presence of juvenile CCV steelhead in the summer and fall months. Juvenile CCV steelhead rear in fresh water from one to three years. 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 capture in the rotary screw traps, and passage estimates may underestimate these life stages.

8.4.2 Seasonal Operations and Whiskeytown Reservoir Operations

The Trinity Reservoir supply and operations are in coordination 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 Department of the Interior's 2000 Trinity River Mainstem Fishery Restoration Record of Decision (2000 ROD) seasonally regulates trans-basin diversions to 55 percent of the approximately 1.2 million acre-feet annual inflow on a 10-year average basis, which impacts Reclamation's temperature operations and CVP deliveries on the Sacramento River. Water diversions from the Trinity Division to the Shasta Division have averaged about 650,000 thousand acre-feet per year from 2001-2018 (Trinity River Restoration Program).

Trinity River water is diverted from Lewiston Reservoir to Whiskeytown Reservoir through the Clear Creek Tunnel and Carr Power Plant. The diverted water flows through Whiskeytown Reservoir, and is diverted either into Spring Creek Tunnel, through Spring Creek Power Plant, and into Keswick Reservoir where it is released into the upper Sacramento River; or is released from Whiskeytown Dam into Clear Creek.

The Whiskeytown Reservoir Operations proposed action component includes: (1) regulation of inflows for power generation and recreation; (2) support of upper Sacramento River temperature objectives; and (3) providing releases to Clear Creek to meet water temperature objectives for CV spring-run and CCV steelhead. Whiskeytown Reservoir has a capacity of 241 thousand acre-feet at the 1,210 feet reservoir surface elevation, and current operations build storage in the spring. It is drawn down by approximately 35 thousand acre-feet from November through April to regulate wet-season runoff for winter and spring flood management. Heavy rainfall events and flood control management occasionally result in glory hole spillway discharges into Clear Creek. Although Whiskeytown Reservoir 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, located immediately downstream from Whiskeytown Dam. Whiskeytown Reservoir also supplies domestic water to the Clear Creek Community Services District.

The volume of water moving through Lewiston and Whiskeytown reservoirs affects Sacramento River and Clear Creek water temperatures. There are two temperature control curtains located in Whiskeytown Reservoir, designed to work in tandem to reduce mixing of cold water inflows and warm surface waters, and to enhance cold water availability to the Whiskeytown Reservoir outlets at Spring Creek Tunnel (1,085 ft. elevation) and Whiskeytown Dam (Clear Creek Technical Team 2018; Vermeyen 1997). The Oak Bottom Temperature Control Curtain (replaced in May 2016) is located at the Carr Powerplant 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 ft. elevation, and the lower one at 972 ft. elevation) to release water into Clear Creek. Reclamation evaluates thermal profiles of Whiskeytown Reservoir 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 and Trinity Reservoirs to support operational decisions for water temperature management.

Whiskeytown Reservoir Operations related to Clear Creek releases include water temperature management, minimum instream base flows, and spring attraction and channel maintenance flows described in Section 2.5.3.4.

8.4.3 Spring Creek Debris Dam

Spring Creek Debris Dam was constructed to regulate runoff containing debris and acid mine drainage from Spring Creek, a tributary to the Sacramento River that enters Keswick Reservoir. Runoff containing acid mine drainage from Iron Mountain Mine is stored in Spring Creek Reservoir. In January 1980, Reclamation, CDFW, and State Water Resource Control Board executed a memorandum of understanding to implement actions that protect the Sacramento River system from heavy metal pollution from acid mine drainage in Spring Creek and adjacent watersheds. Since 1990, concentrations of toxic metals have been reduced by approximately 95 percent from what historically emptied into the Sacramento River. This reduction was due to significant remedial actions by the EPA including the completion of (1) Minnesota Flats Iron Mountain Mine Acid Mine Drainage Treatment Plant in 1994, (2) Slickrock Creek Retention Reservoir in 2004 and, (3) dredging of contaminated sediments from the Spring Creek arm of Keswick Reservoir in 2009-2010. Due to improvements in water quality, operation of the Spring Creek Debris Dam and Shasta Dam have deviated from the 1980 memorandum of understanding, and as a result, Reclamation, CDFW, SWRCB, and EPA are progressing towards a revised memorandum of understanding with similar guidelines to what Reclamation is proposing for interim operations as part of this proposed action.

Reclamation is proposing to implement operational actions involving water releases at Spring Creek Debris Dam, Spring Creek Power Plant, and Keswick Reservoir, that result in meeting water quality criteria standards for concentrations of copper and zinc from acid mine drainage pollution from Spring Creek at a compliance point in the Sacramento River, to protect aquatic life. Reclamation proposes to conduct water quality monitoring, and with increased frequency during Spring Creek Debris Dam spillway releases, or when there are drops below the minimum elevation threshold in Spring Creek Reservoir. The operation described herein is also dependent on the water treatment capabilities afforded by EPA.

Storage elevation levels in Spring Creek Reservoir determine the operational action used to maintain water quality criteria in the Sacramento River. Actions include (1) undiluted controlled releases when storage is between 720 and 795 feet, typically December through June, (2) dilution releases through the spillway, combined with increased releases from Keswick Dam, when storage exceeds 795 feet, and (3) no releases from the reservoir when storage is below 720 feet, and instead a minimum dilution flow of 250 cfs from Spring Creek Power Plant. Reclamation operates to maintain Spring Creek Reservoir storage elevation between 720 and 795 feet. Reclamation assumes operational scenarios for levels above or below this range would occur very infrequently.

In the unlikely situation when the Spring Creek Debris Dam spillway is used, Reclamation anticipates an “emergency” relaxation of EPA’s criteria for a 50 percent increase in the objective concentrations of copper and zinc. Although the general operational goal is to avoid use of the Spring Creek Debris Dam spillway, some storm events or series of storm events are unavoidable. The spillway operation typically occurs during a large storm or series of storm events, January through April, and are coincident with large flood management flows released from Keswick Dam. In recent years EPA, Reclamation, CDFW, and the RWQCB have agreed not to use the emergency criteria until a spill is imminent. During significant rain events Spring Creek Debris Dam releases may target a dilution ratio with Keswick releases to achieve an acceptable water quality below Keswick Dam. Spring Creek Reservoir spillway dilution flows from Keswick are expected to be coincident with large flood management flows and are not expected to impact water supply or cold-water pool resources. Reclamation also does not plan to operate Spring Creek Reservoir below 720 feet elevation to avoid significant degraded water quality when reservoir soils are exposed, and assumes this would only occur in a very rare situation. Any time dilution flows are necessary, Reclamation’s objective is to minimize the build-up of toxic metals in the Spring Creek arm of Keswick Reservoir. To accomplish this, the releases from the debris dam are coordinated with releases from Spring Creek Powerplant (Spring Creek Power Plant draws water from Whiskeytown Reservoir) to keep the metals in circulation within the main body of Keswick Reservoir.

In conjunction with the EPA remedial actions, the proposed operation of Spring Creek Debris Dam will be operated to decrease concentration levels of zinc and copper entering the Sacramento River, and minimize adverse physiological effects to listed salmonids and green sturgeon.

Spring Creek Debris Dam spillway releases will likely only occur during large storms from January through April when the Spring Creek Reservoir is over 795 feet, resulting in higher flows into the Sacramento River. In addition, higher Keswick releases will be needed to dilute contaminants being spilled from the Spring Creek Debris Dam, and achieve the water quality criteria level below Keswick Dam. Increased Keswick releases during these months could have the potential to impact water supply and cold-water pool resources reserved for summer and fall months for the Sacramento River. However, because Spring Creek Reservoir spillway dilution flows from Keswick are expected to coincide with large flood management flows, they are not expected to impact water supply or cold-water pool resources. Flow changes in the Sacramento

River between January and June have the potential to impact CCV steelhead spawning, and CV spring-run Chinook salmon and CCV steelhead juvenile rearing. Large increases may expose salmonid eggs in redds to risk of scour and fine sediment infiltration, and flow decreases may strand or isolate juvenile salmonids in side channels downstream of Keswick Dam.

On the rare occasion when Spring Creek Reservoir is below 720 feet storage elevation and increased releases from Spring Creek Powerplant are needed for dilution flows, additional water draw from Whiskeytown Reservoir may impact cold-water pool resources. Subsequent warmer releases from the reservoir into Clear Creek during CV spring-run Chinook salmon holding, spawning, and egg incubation could result in decreased egg survival.

In any operational scenario, NMFS expects contaminants to remain within standards and physiological effects of contaminants on listed fish are not expected to occur. Reclamation will monitor water quality in the Sacramento River as described in the 1980 memorandum of understanding, and with increased sampling frequency during dilution flows, and altered operations if necessary to ensure levels of contaminants are within standards.

Reclamation expects to maintain reservoir levels, such that dilution flow operations are not expected to occur. As the EPA treatment plant is the first defense to keeping acid mine pollution within water quality standards in the Sacramento River, NMFS adopts Reclamation's assumption regarding proposed operation of Spring Creek Debris Dam. Therefore, exposure to Sacramento River flow, water temperature, or contaminant stressor effects in Clear Creek are not expected to occur to extents that would result in impacts to listed species, and are not carried forward in this analysis.

8.4.4 Clear Creek

This section addresses the portion of Trinity River Division water that is diverted into Whiskeytown Reservoir and becomes part of Clear Creek releases. Reclamation proposes to provide releases from Whiskeytown Dam into Clear Creek to: (1) to meet water temperature objectives for CV spring-run and CCV steelhead, (2) provide minimum instream base flows, and (3) create pulse flows for both attraction of adult CV spring-run Chinook salmon and channel maintenance. In years when channel maintenance flows do not occur, Reclamation proposes to use mechanical methods to mobilize gravel or shape the channel, if needed, to meet biological objectives. Each proposed action component and their effects on listed species in Clear Creek are described below.

8.4.4.1 Clear Creek Temperature Management

Reclamation proposes to manage Whiskeytown Dam releases to meet a daily average water temperature of (1) 60°F from June 1 through September 14, and (2) 56°F or less from September 15 to October 31 at the U.S. Geological Survey Igo stream gauging station, located at river mile 11.0 on Clear Creek (U.S. Geological Survey 2019). In Critical or Dry water year types (based on the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (California Data Exchange Center (Department of Water Resources 2019)), Reclamation will operate to as close to these temperatures as possible, but acknowledges temperature criteria may not be met. During the water temperature management period, Reclamation proposes to increase minimum instream base flows when needed to meet criteria.

Water temperature criteria in the proposed action are the same as current operations, which were developed to reduce thermal stress to CV spring-run Chinook salmon during holding, spawning, and egg incubation, and over-summering CCV steelhead.

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 Reservoir 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 15 to October 31 spawning period (as discussed below) has been more difficult to meet due to changes in water diversion patterns that have resulted in longer residency time and warming in Whiskeytown Reservoir. By September, the cold-water pool in Whiskeytown 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. Operational strategies that have been used to offset this limited cold water availability have included early recognition to use different outlet configurations at Whiskeytown Dam to conserve and access colder water during periods of thermal stress (He and Marcinkevage 2016). Additional operational strategies that have been used in the summer to conserve cold water for the CV spring-run Chinook salmon spawning period include reducing Clear Creek releases in July, and avoiding full power peaking operations at Trinity, Carr and Spring Creek powerhouses (Clear Creek Technical Team 2013). The recent replacement of the torn temperature control curtains in Whiskeytown Reservoir are expected to help to provide more cold water, and Reclamation's Technical Service Center is currently evaluating of the performance of both temperature curtains, with a final report expected in 2019.

For the Clear Creek analysis, Reclamation used the HEC-5Q model, to simulate temperature conditions on the rivers affected by CVP and SWP operations, using CalSimII output for Whiskeytown Reservoir. Output was 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. The current operating scenario refers to the current modeling representation of project operations at the time of consultation. Because the proposed temperature management is the same as current operations, the proposed action and current operating scenario modeling results are similar.

To evaluate thermal conditions for adult and juvenile salmonids in Clear Creek, exceedance plots of monthly mean water temperatures were examined with consideration of the temperature criteria under various water year types (Figure 57). 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 criterion changes on September 15, it is difficult to compare monthly temperatures to the different criterion period.

HEC-5Q modeling results showed that water temperature objectives are met at Igo each month under the proposed action component, except in Critical water year types, which are expected to occur in 15 percent of years (Table 36). In Critical water year types, monthly average temperatures exceeding 56°F are expected to occur approximately seven percent of the time in September and October (Figure 58). Plots compare the (current operating scenario6) to the Proposed Action (PA5woVSA), and the probability that monthly average water temperatures (degrees Fahrenheit) will occur. Because the temperature criteria changes on September 15, it is difficult to compare monthly temperatures to the different criteria periods.

Table 36. Modeling results from HEC-5Q at the Igo gauging station temperature criteria compliance point.

	Monthly Temperature (DEG-F)											
Statistic	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Probability of Exceedance												
10%	55.0	52.2	48.7	46.3	46.1	47.3	49.1	50.3	53.1	56.6	56.6	55.6
20%	54.2	51.8	48.2	45.6	45.6	46.9	48.6	49.9	52.5	56.0	56.2	54.7
30%	53.8	51.1	47.1	45.2	45.2	46.5	48.1	49.4	51.9	55.4	55.7	54.3
40%	53.4	50.9	46.8	44.9	45.0	46.1	47.9	49.2	51.6	55.2	55.6	54.0
50%	53.0	50.6	46.5	44.6	44.8	45.9	47.6	48.9	51.2	55.0	55.3	53.5
60%	52.4	50.4	46.3	44.3	44.5	45.7	47.4	48.6	50.9	54.6	55.2	53.1
70%	51.8	50.2	46.1	44.1	44.2	45.5	47.2	48.4	50.7	54.5	54.9	52.9
80%	51.2	49.8	45.9	43.9	44.0	45.3	46.9	48.1	50.3	54.2	54.5	52.4
90%	50.7	49.4	45.5	43.6	43.8	44.8	46.4	47.4	49.6	53.8	54.0	52.1
Long Term												
Full Simulation Period[a]	53.0	50.8	46.9	44.8	44.9	46.0	47.7	48.9	51.4	55.0	55.3	53.8
Water Year Types[b,c]												
Wet (32%)	51.4	50.1	46.5	44.5	44.5	45.5	47.2	48.6	50.9	54.9	55.0	52.8
Above Normal (16%)	51.9	50.1	46.4	44.6	44.6	45.7	47.4	48.7	50.9	54.8	54.9	52.7
Below Normal (13%)	53.1	51.0	46.8	44.2	44.5	45.9	47.6	48.5	50.9	55.0	55.2	53.5
Dry (24%)	53.6	51.1	47.2	45.0	45.1	46.3	47.9	48.9	51.3	55.0	55.7	54.2
Critical (15%)	56.3	52.3	47.5	45.7	46.0	47.2	48.9	50.1	53.4	55.5	56.2	56.7

[a] *Based on the 82-year CalSimII simulation period.*
[b] *As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (State Water Resources Control Board 1999).*
[c] *These results are displayed with calendar year type sorting.*

Source: ROC on LTO biological assessment, Appendix D, Attachment 3-4, Table 3-3

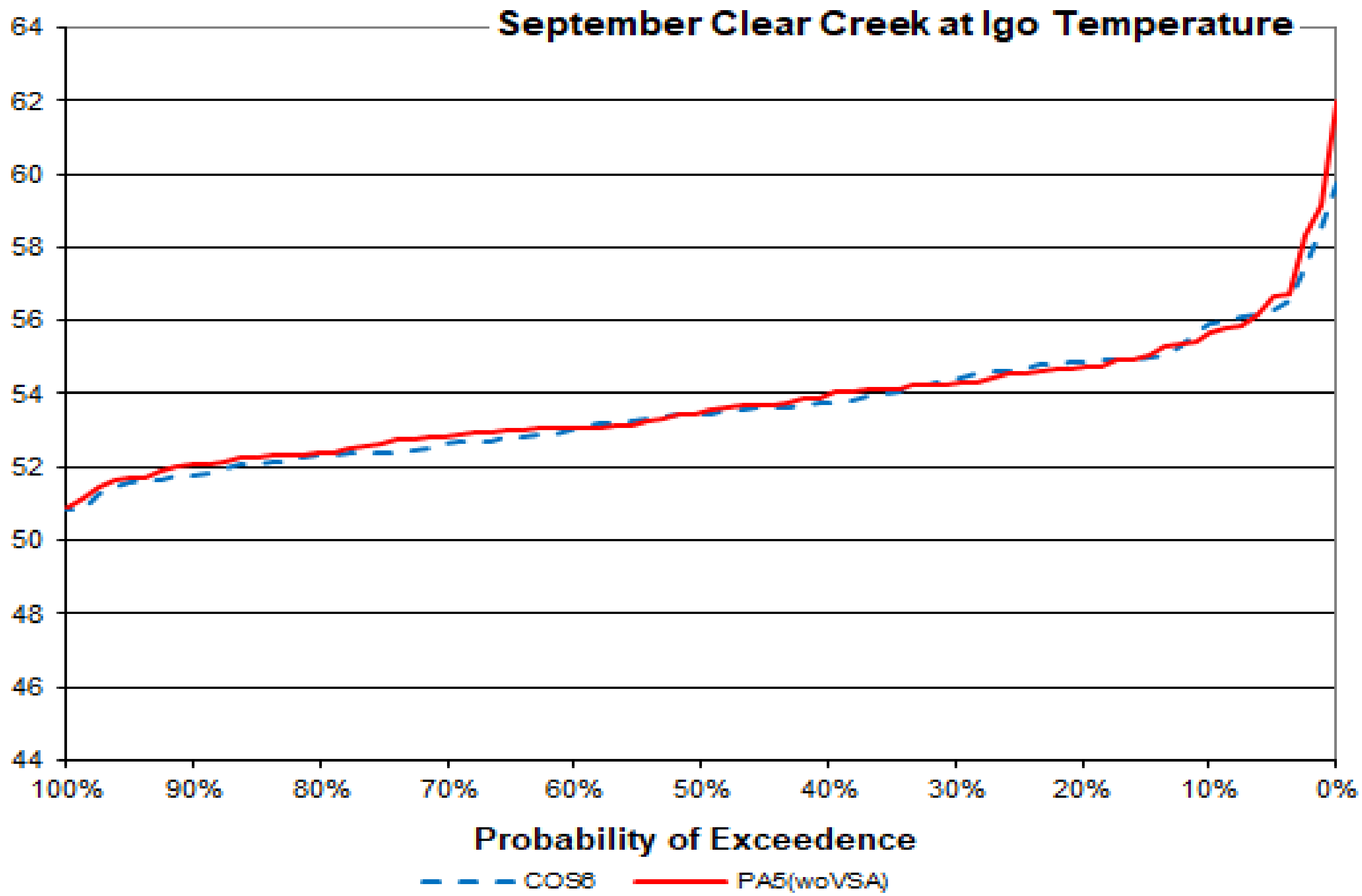


Figure 57. HEC-5Q modeling exceedance plots of the current operating scenario for September atat the Igo gauging station temperature compliance point.

source: ROC on LTO biological assessment

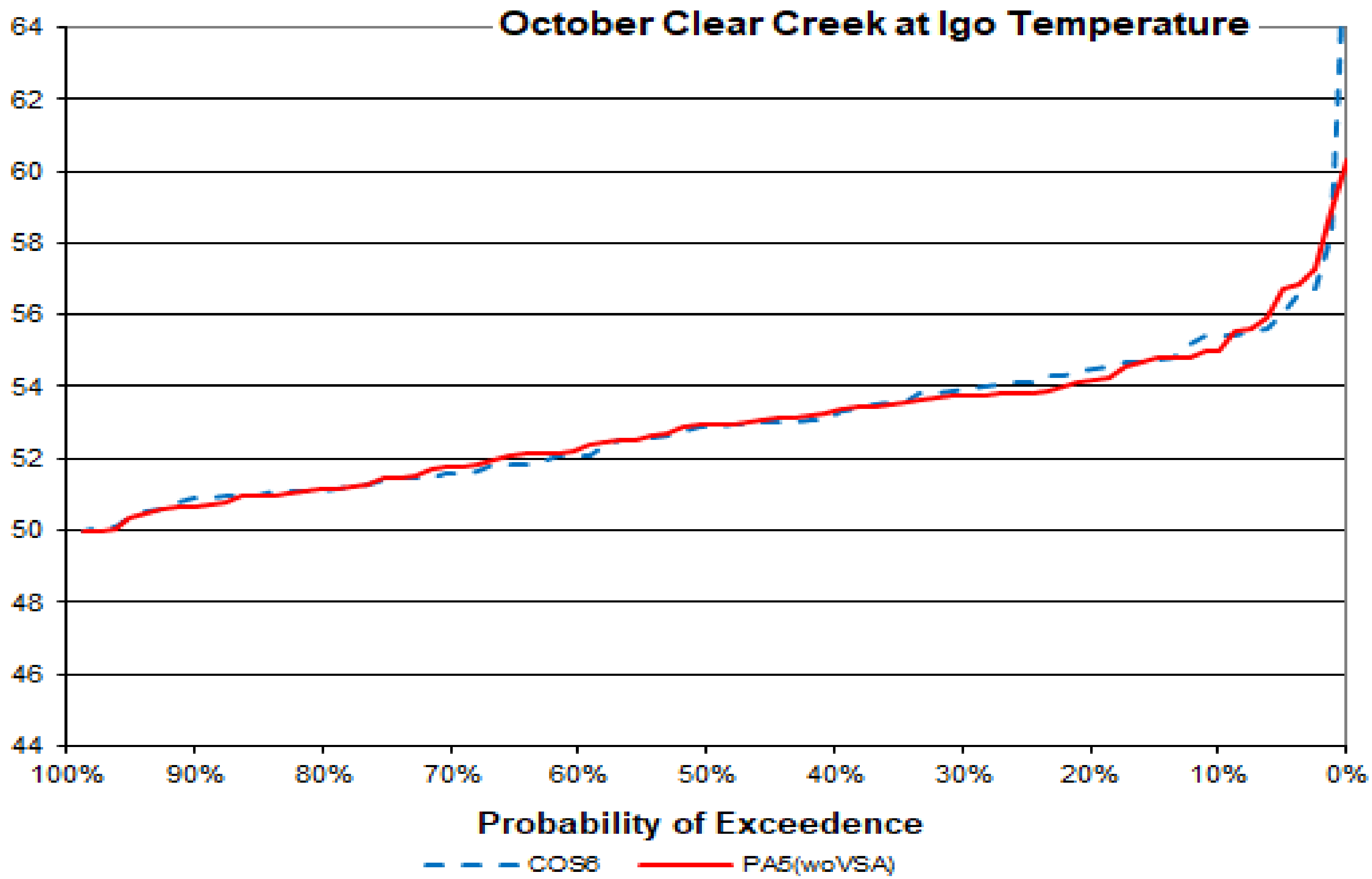


Figure 58. HEC-5Q modeling exceedance plots of the current operating scenario for October at the Igo gauging station temperature compliance point.

source: ROCLTO biological assessment

The water temperature criteria as proposed, have been in place in Clear Creek since 1999. Since 1999, daily average water temperatures have generally been below 60°F at Igo during the summer holding period (Figure 59). However, water temperatures have exceeded 56°F during the spawning period, and exceedance occurs more frequently in drier water year types (Figure 60; criterion=60 °F from June 1-Sept 14; and ≤56°F September 15-October 31). In general, exceedance occurs when the cold-water pool is depleted in Whiskeytown Reservoir.

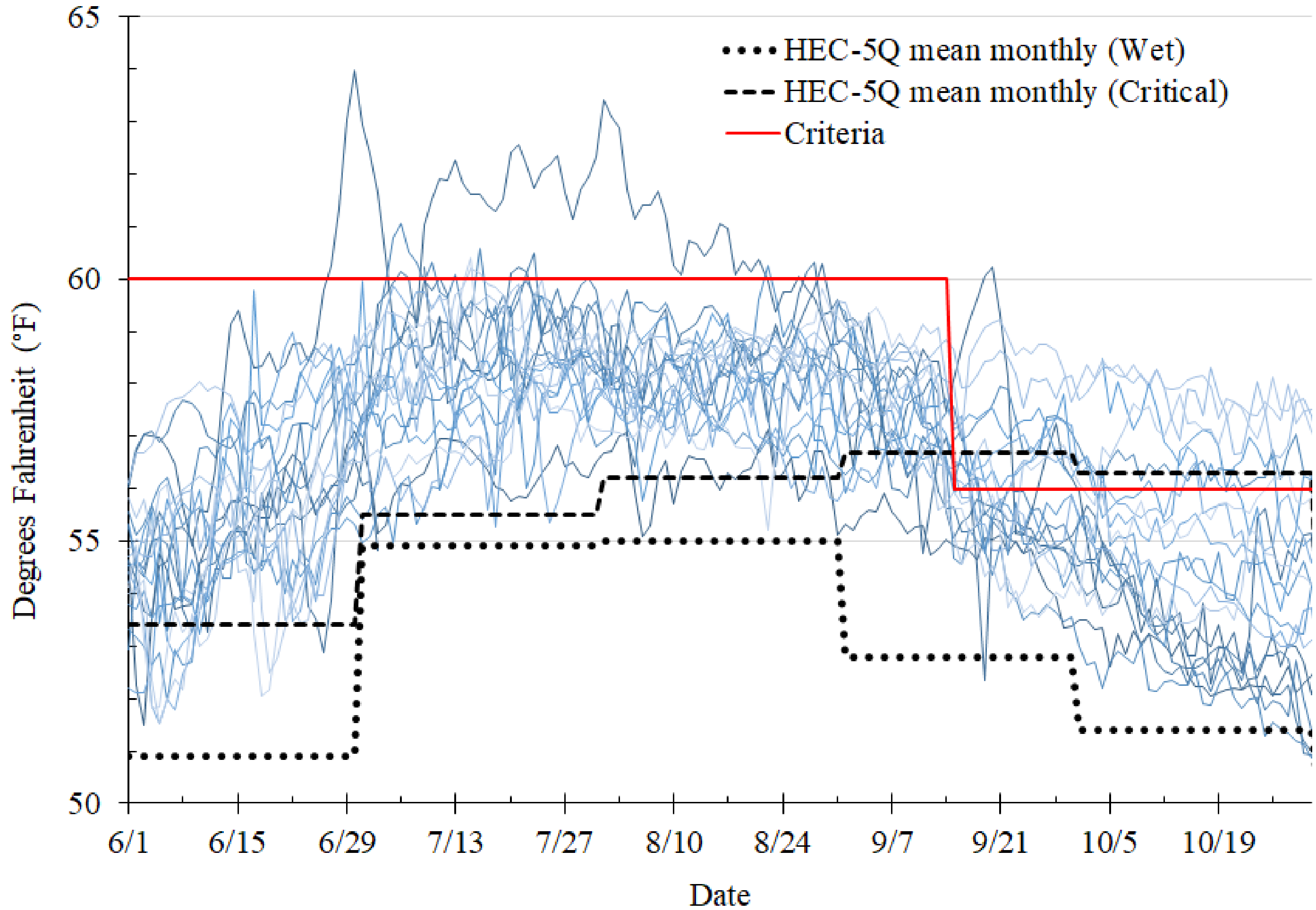


Figure 59. Daily average water temperatures during the water temperature management season at the U.S. Geological Survey Igo gauge on Clear Creek, 1999 to 2018. HEC-5Q monthly water temperature modeling during Sacramento Valley Index water year type Critical and Wet are shown for comparison.

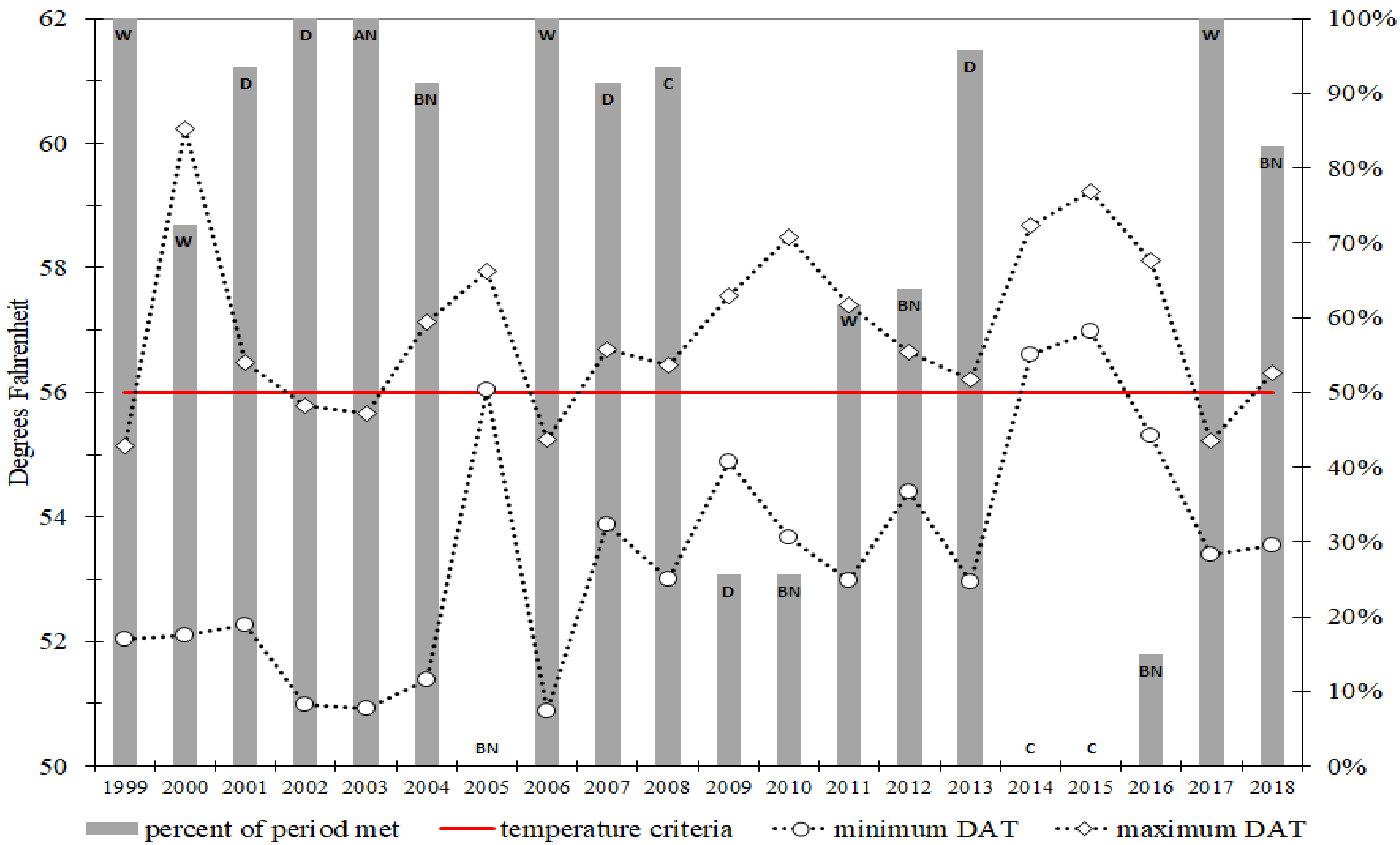


Figure 60. Minimum and maximum daily average water temperatures (DAT) during the fall water temperature management period (Sept 15-Oct 31) for CV spring-run Chinook salmon spawning, when DAT at the U.S. Geological Survey Igo stream gauging station (Igo), located at river mile 11.0 on Clear Creek, are managed to ≤56°F, 1999-2018. Bars correspond to the y axis on the right, and represent the percent of days DAT were met within the period, and indicate the Sacramento Valley Index water year type (W=wet; AN=above normal; BN=below normal; D=dry; and C=critical).

The mouth of Clear Creek is the downstream extent of (1) juvenile rearing habitat and outmigration of CV spring-run Chinook salmon and CCV steelhead, and (2) CCV steelhead spawning habitat. Water temperatures at the mouth during the temperature management season generally represent the warmest temperatures in Clear Creek. The mouth is also the entry point of upstream adult migration where water temperatures are first experienced. Daily average water temperature measurements near the mouth of Clear Creek from 1999 to 2018 range above HEC-5Q monthly modeled temperatures during the temperature compliance period (Table 37, Figure 61). The discrepancy between actual and modeled temperatures may be due to differences in locations. Particularly in the summer months when the Sacramento River releases are high, flows create backwater into Clear Creek and cool the mouth, which may be influencing the model results.

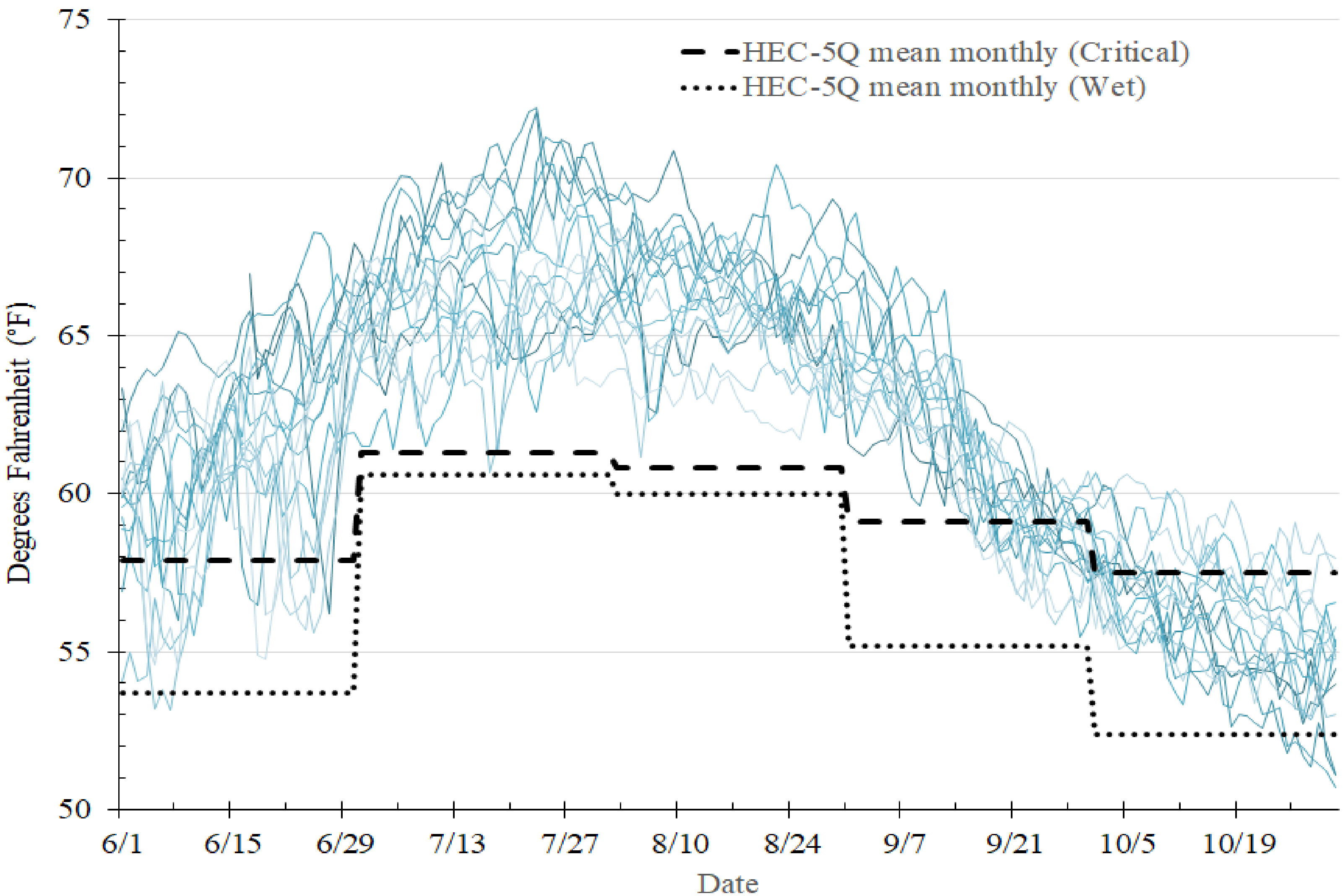


Figure 61. Daily average water temperatures during the temperature compliance period near the mouth of Clear Creek for the years 1999 to 2018 (Chamberlain 2019c). The proposed action HEC-5Q monthly water temperature modeling results during Sacramento Valley Index water year type Critical and Wet are shown for comparison.

Table 37. Modeling results from HEC-5Q at the mouth of Clear Creek.

	Monthly Temperature (DEG-F)											
Statistic	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Probability of Exceedance												
10%	56.0	52.6	48.9	46.6	46.6	48.4	50.9	52.1	56.9	62.2	61.4	57.7
20%	55.1	52.1	48.3	45.9	46.3	48.2	50.3	51.8	55.5	61.7	61.0	56.9
30%	54.6	51.6	47.4	45.5	45.9	47.9	49.8	51.3	54.9	61.1	60.7	56.6
40%	54.2	51.2	47.0	45.3	45.8	47.4	49.5	50.9	54.5	60.8	60.5	56.3
50%	53.9	50.9	46.8	44.9	45.5	47.0	49.2	50.7	54.1	60.6	60.2	55.8
60%	53.1	50.7	46.5	44.7	45.2	46.9	49.1	50.5	53.8	60.4	60.1	55.4
70%	52.7	50.5	46.3	44.3	45.0	46.6	48.9	50.2	53.4	60.1	59.8	55.2
80%	52.2	50.1	46.1	44.1	44.7	46.4	48.5	49.9	53.1	59.9	59.4	54.8
90%	51.8	49.7	45.6	43.9	44.5	45.9	48.1	49.1	52.5	59.5	59.1	54.4
Long Term												
Full Simulation Period[a]	53.9	51.1	47.0	45.1	45.6	47.2	49.4	50.8	54.5	60.7	60.2	56.1
Water Year Types[b,c]												
Wet (32%)	52.4	50.4	46.7	44.9	45.2	46.6	48.8	50.4	53.7	60.6	60.0	55.2
Above Normal (16%)	52.8	50.4	46.6	45.0	45.3	46.9	49.0	50.6	53.8	60.5	59.8	55.0
Below Normal (13%)	53.9	51.3	47.0	44.5	45.2	47.0	49.4	50.3	53.8	60.6	60.0	55.7
Dry (24%)	54.5	51.4	47.4	45.2	45.8	47.5	49.6	50.7	54.3	60.7	60.6	56.4
Critical (15%)	57.5	52.7	47.6	46.0	46.8	48.5	50.9	52.3	57.9	61.3	60.8	59.1

[a] Based on the 82-year CalSimII simulation period.
[b] As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (State Water Resources Control Board 1999).
[c] These results are displayed with calendar year type sorting.

Source: ROC on LTO bi biological assessment, Appendix D, Attachment 3-4, Table 4-3

8.4.4.1.1 Central Valley Spring-run Chinook Salmon Exposure, Response, and Risk

The water temperature management season encompasses the CV spring-run Chinook salmon adult holding, spawning, and egg incubation/alevin development life stages, and ends just prior juvenile emergence. A small number of sub-yearling juveniles are present during the temperature management season.

The proposed action HEC-5Q monthly water temperature modeling results during the summer water temperature management period (60°F at Igo from June 1 to September 14) show average monthly water temperatures well below the 60°F criterion from June to August in all water year types (Table 36 and Figure 59). Under current operations, daily average water temperatures at Igo from 1999-2018 were consistently warmer than what was modeled for the proposed action (Table 36 and Figure 59). Daily average water temperatures have only exceeded 60°F at Igo for a few days in some years under current operations (except in 2000, when flow releases were low to accommodate the removal of Saeltzer Dam). Under current operations, 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 water temperature criterion in the summer, and will likely be needed under the proposed action. Use of base flows in the summer may degrade the cold-water pool in Whiskeytown Reservoir, decreasing the ability to meet fall spawning water temperature criterion.

At the mouth of Clear Creek from June through August, water temperatures greater than 68°F 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 from 1999 to 2018 were generally within optimal ranges for adult migration in June; suboptimal (>68ºF) during some periods in July and August; and occasionally over 70ºF (when migration generally stops) in July (Figure 61). 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 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.

Daily average water temperatures are likely to continue to remain below 60°F upstream of the Igo compliance point under the proposed action based on HEC-5Q temperature modeling results, and observed daily average water temperature data under current operations (Figure 59). However, monitoring from 2003-2016 has shown that, annually, an average 49 percent (range = 25 to 73 percent) of the adult CV spring-run Chinook salmon population index is located downstream of the Igo temperature compliance point at river mile 11.0 (Figure 62); these fish are therefore more likely to be exposed to water temperatures greater than 60°F. In addition, after the segregation weir is installed in late August, an average of 20 percent (range 1 to 36 percent) of the population index is located downstream of the segregation weir at river mile 8.2 or 7.5 (Figure 62) and as far downstream as river mile 4, where in some years, daily average water temperatures reach over 65°F (Clear Creek Technical Team 2016). The CV spring-run Chinook salmon adults downstream of the segregation weir are also subject to hybridization with fall-run

Chinook salmon, and their incubating eggs would be exposed to impacts from suboptimal temperatures, and redd superimposition by fall-run Chinook salmon.

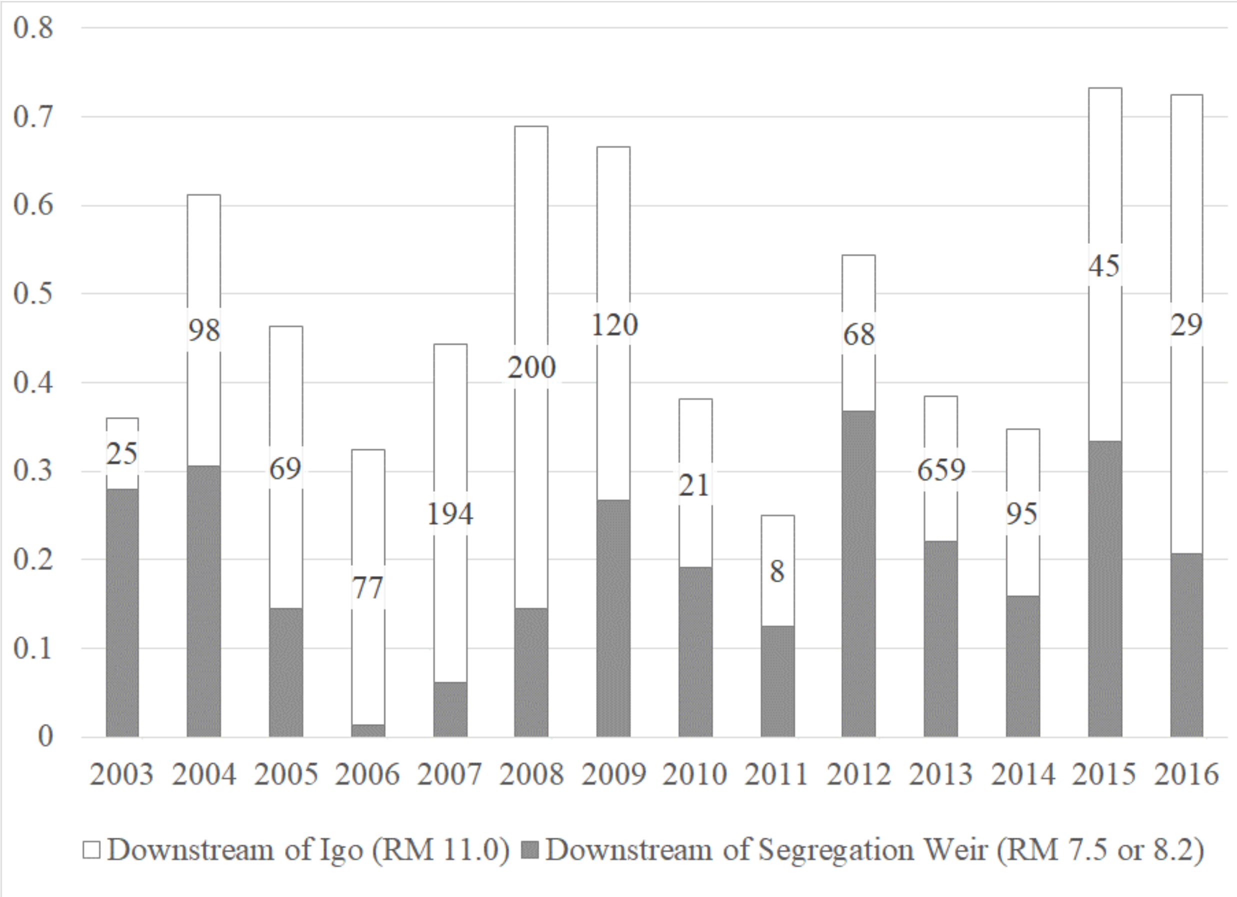


Figure 62. Annual proportion of the Central Valley spring-run Chinook salmon population index located downstream of the Igo temperature compliance point, and downstream of the segregation weir, in Clear Creek, 2003 to 2016. Label at each stacked bar represents the annual population index.

Source: Chamberlain (2019b)

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. Daily average water temperatures are likely to remain below 60°F upstream of the Igo compliance point under the proposed action and to provide suitable holding habitat during the summer water temperature management period. The current adult CV spring-run Chinook salmon holding distribution (Figure 62) will likely continue under the proposed action.

During the fall water temperature management period (≤56°F at Igo from September 15-October 31) the proposed action HEC-5Q monthly water temperature modeling shows difficulty meeting temperatures in Critical water year types, which are expected to occur in 15 percent of years. From 1999 to 2018, the temperature criterion has been exceeded during the spawning period in 14 of 19 years (excluding 2000) at Igo, and exceedance has not been limited to Dry and Critical water year types (Figure 60). The temperature criterion was exceeded during the entire spawning period in 2005, 2014, and 2015 (Figure 60). Additionally, in 4 years (2009, 2014-2016) average daily water temperatures continued to be above 56°F at the Whiskeytown Dam outlet, and at Igo, through mid-November. From 2003-2016, results from monitoring data have shown an average of 42 percent (range=30 to 64 percent) of the CV spring-run Chinook salmon redd index (redd count from Whiskeytown Dam to the segregation weir at river mile 7.5 or 8.2) was located downstream of the temperature compliance point at Igo (Figure 63). In addition, an average of 8 percent (range = 0 to 26 percent) of the CV spring-run Chinook salmon annual redd index begins before September 15 (Provins 2019), which would be exposed to the 60°F summer water temperature management period.

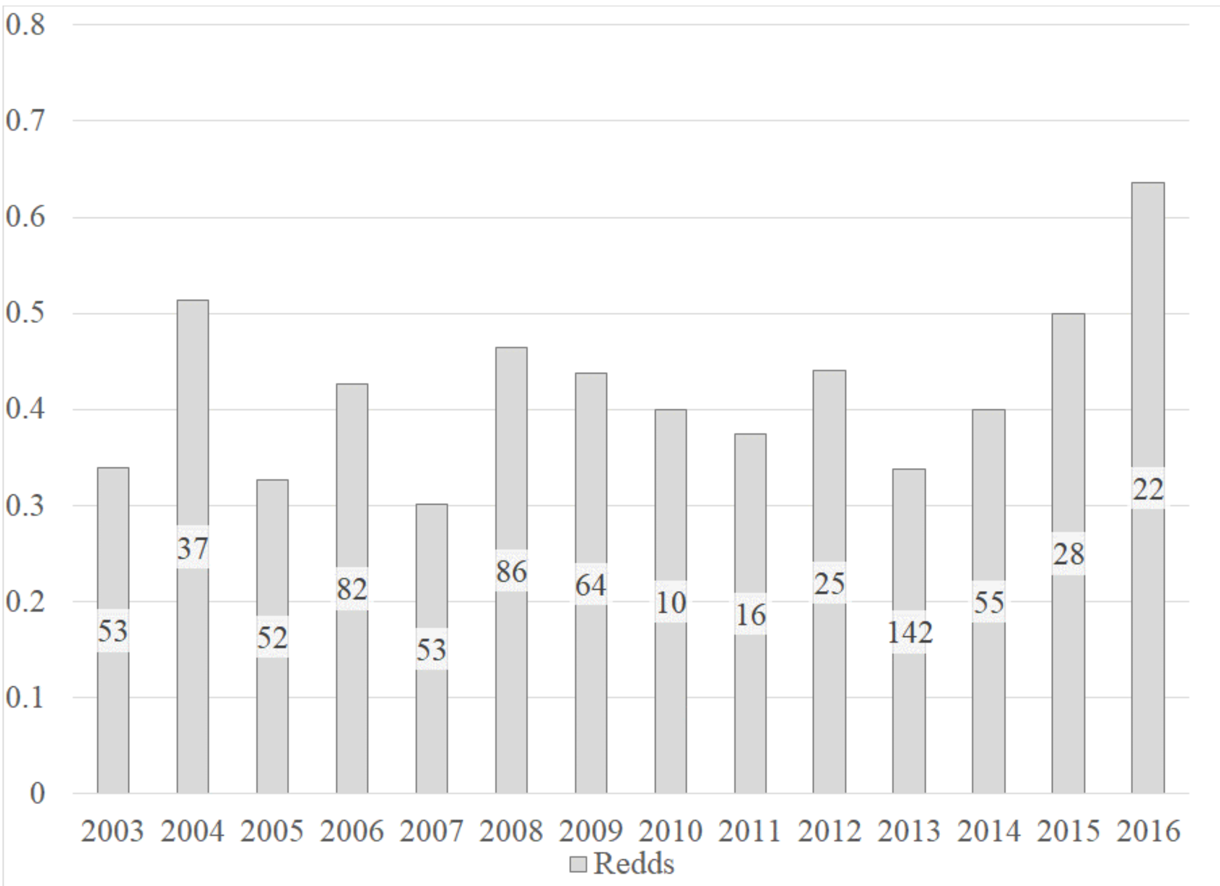


Figure 63. Annual proportion of Central Valley spring-run Chinook salmon redd index located downstream of the Igo gauge in Clear Creek, 2003 to 2016. Labels at each bar represent the annual redd index (redd count between Whiskeytown Dam (river mile 18.3) and the segregation weir at river mile 7.5 or 8.2).

Source: Chamberlain (2019b)

Spawning gravel additions have created suitable spawning habitat in a 1-mile reach 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, redds located further upstream experience colder water temperatures in Clear Creek, especially during the earliest stages of incubation. In an evaluation of water temperature exposure at Clear Creek CV spring-run Chinook salmon redd locations, from 2008-2018, eggs experienced mean daily temperatures over 56°F for approximately 25 percent of incubation days (Figure 64).

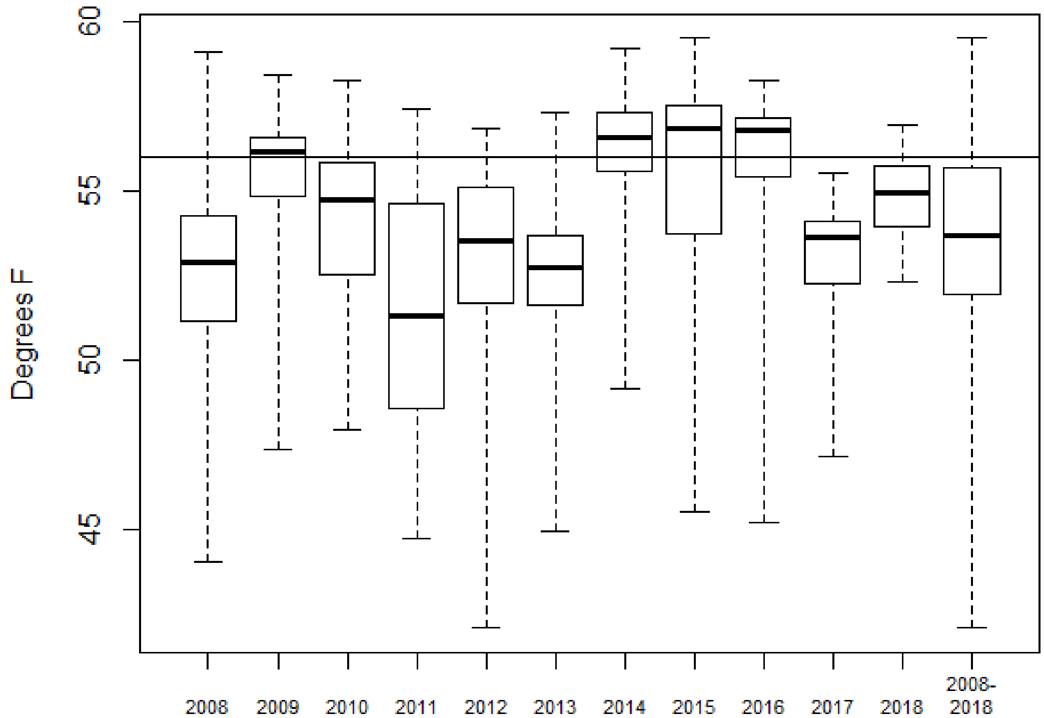


Figure 64. Water temperature exposure of Central Valley spring-run Chinook salmon incubating eggs in Clear Creek, 2008 to 2018. Exposure was calculated using daily average water temperatures at redd locations through emergence. Loggers are about every two miles, and temperatures are interpolated to the redds.

Source: Provins (2019)

The 56°F daily average water temperature criterion was incorporated into the 2009 NMFS Opinion RPA to protect developing CV spring-run Chinook salmon eggs during the incubation period in Clear Creek. However, 56°F daily average water temperatures are suboptimal, and would likely lead to mortality of incubating eggs and reduced survival. Myrick and Cech (2004) determined that water temperatures between 6.1°C (43°F) and 12.2°C (54°F) appear best suited for Chinook salmon egg incubation and larval development. Modeling results from Martin et al. (2017) showed thermal mortality thresholds during the embryonic life stage of Chinook salmon in the Sacramento River were lower than what was previously documented in the laboratory, and hypothesized that egg survival was influenced by mechanisms including water velocity and oxygen in the water around the eggs within the redd. The EPA recommends the use of 13°C (55.4°F) maximum 7-day average of daily maxima (7DADM) criterion for Chinook salmon spawning (U.S. Environmental Protection Agency 2003).

A recent evaluation of the relationship of flow and water temperature on CV spring-run Chinook salmon egg-to-fry survival in Clear Creek similarly concluded that lower water temperatures led to improved survival (Provins 2018). In developing a framework for incorporating water temperatures into recommended flow regimes, 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.

Capture of juvenile CV spring-run Chinook salmon in the Clear Creek rotary screw trap has demonstrated that successful spawning occurs annually. In some years, temperature-dependent mortality and reduced egg-to-fry survival likely contributed to lower than expected juvenile passage indices, based on redd counts. Because there are many physical variables that influence egg-to-fry survival (e.g. levels of dissolved oxygen, fine sediment infiltration in redds, flow and redd scour events), and environmental conditions and error associated with sampling sometimes add uncertainty to passage indices, differentiating temperature-associated mortality from other factors is complicated.

Since the implementation of the 2000 ROD in 2005, the 56°F spawning period criterion was exceeded in 12 of 14 years, and NMFS expects this to continue to occur in similar frequency under the proposed action. Clear Creek CV spring-run Chinook salmon redd distribution and water temperature data under current operations also demonstrate that incubating eggs are exposed to water temperatures greater than 56°F annually. In addition, literature suggests that daily average temperature of 56°F is suboptimal for Chinook salmon egg incubation (Martin et al. 2017; Myrick and Cech 2004; National Marine Fisheries Service 2019a; U.S. Environmental Protection Agency 2003).

While the majority of juvenile CV spring-run Chinook salmon emigrate by early spring, based on annual juvenile passage indices from the rotary screw trap, a small number rear in Clear Creek through the spring and summer and emigrate as sub-yearling smolts and therefore would be present during the water temperature management period. Observations of juvenile CV spring-run Chinook salmon have been made during snorkel surveys in the late spring and summer months (U.S. Fish and Wildlife Service 2007). Daily average water temperatures from 1999 to 2018 ranged from approximately 55°F to 60°F in July and August at Igo (Figure 59), but were generally greater than 65°F near the mouth (Figure 60). 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 three miles of Clear Creek during the water temperature management period would likely be exposed to suboptimal temperatures for rearing (>65°F) and for smoltification (>66.2°F), increasing their susceptibility to stress, disease, predation, and mortality. Based on the typical CV spring-run Chinook juvenile outmigration period, a very small number are expected to be present in summer months, and even less would be located in the lower three miles where water temperatures are suboptimal. Water temperature management under the proposed action is not expected to affect survival of rearing and outmigrating juveniles.

8.4.4.1.2 California Central Valley Steelhead Exposure, Response, and Risk

Migrating adults and rearing juveniles from various year classes would be present in Clear Creek during the temperature management period. Various 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 (U.S. Environmental Protection Agency 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.

Water temperatures may be suboptimal for adult CCV steelhead during the earliest migration and holding period. Within the temperature management period, based on preliminary adult passage data from the video monitoring station located at the mouth of Clear Creek from 2014 to 2018, an average of 40 percent (range 12 to 71 percent) of adult CCV steelhead migrated into Clear Creek from mid-August through October (Cook 2019; Killam 2019a). Only a small portion (average 6 percent) enter Clear Creek before September 15, before flow releases increase and the temperature criterion 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, and are below 60°F consistently beginning in October (Figure 61). Based on a literature review of salmonid water temperature criteria, Richter and Kolmes (2005) summarized that water temperatures near 70°F block 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 (U.S. Environmental Protection Agency 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 not expected during the water temperature management period. CCV steelhead adults hold in Clear Creek until spawning begins in mid-December, and are restricted downstream of the segregation weir until early November when it is removed. Water temperatures are generally adequate for holding during this time, and therefore 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 over-summering rearing juvenile CCV steelhead. Richter and Kolmes (2005) reported ideal conditions for CCV steelhead juvenile growth to be below 19°C (66.2°F), and optimal at 14-15°C (57.2-59°F). 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 6 and 18°C (42.8-64.4°F), compared to 6 and 13°C (42.8-55.4°F)).

During July and August, historically months with the warmest water temperatures observed in Clear Creek, the proposed action HEC-5Q modeling results at Igo and the mouth showed monthly average water temperatures are generally within optimal ranges for juvenile CCV steelhead rearing and growth (Table 36 and Table 37). Daily average water temperatures from 1999 to 2018 ranged from approximately 55°F to 60°F in July and August at Igo (Figure 59), but generally ranged from approximately 65°F to 70°F near the mouth at the lowest extent of rearing habitat (Figure 60). The highest density of CCV steelhead spawning occurs in the lower six miles of Clear Creek. Any juveniles rearing in the furthest downstream three miles of Clear Creek during the summer water temperature management period would likely be exposed to suboptimal temperatures, increasing their susceptibility to stress, disease, predation, and mortality. However, CCV steelhead juvenile outmigration generally does not occur in the summer so they would not be exposed to the warmest water temperatures at the mouth, and rearing juveniles would access upstream habitat with suitable water temperatures. Based on fresh-water rearing life history of juvenile CCV steelhead, which is one to three years, a large portion are expected to be present in Clear Creek during the summer months. The majority are expected to access rearing habitat with suitable water temperatures, and therefore exposure to suboptimal water temperatures would be limited to a small number of individuals. Although this exposure is expected to result in sublethal and lethal effects, some levels of exposure to warmer water temperatures may also be beneficial and a contributing factor influencing rates of anadromy (Sloat and Reeves 2014).

8.4.4.2 Clear Creek Flow Releases

Reclamation proposes to release a minimum instream base flow of 200 cfs from October 1 through the end of May and 150 cfs from June through September in Clear Creek, in all water year-types except Critical, when flows may be reduced based on available water from Trinity Reservoir. Additional flows may be required for fall temperature management. Base flows determine the amount of aquatic habitat available for most of the year based on the current channel configuration.

Reclamation also proposes to create (1) spring attraction pulse flows to attract and encourage upstream movement of adult CV spring-run Chinook salmon into Clear Creek, and (2) channel maintenance pulse flows to provide sediment transport and geomorphic benefit. Up to 10 thousand acre-feet for each type of pulse flow would be available annually. As described in the Appendix C of the ROC on LTO biological assessment, the Clear Creek Implementation Team will provide pulse flow shaping and scheduling recommendations in coordination with Reclamation.

CalSimII is a reservoir-river basin model used to simulate the coordinated operation of the CVP and SWP over a range of hydrologic conditions. CalSimII modeling assumptions included projected climate change, and sea level rise assumptions corresponding to Year 2030. Despite detailed model inputs and assumptions, the CalSimII results differ from real-time operations under stressed water supply conditions. Reclamation proposes to adjust operations when necessary, depending on conditions and constraints, to meet legal and contractual obligations.

Assumptions:

Modeled runs assumed 200 cfs base flow from October through May, and 10 thousand acre-feet for spring attraction pulse flows in May and June, in all but Critical water year types. While 150 cfs releases are proposed from June through September (Harrison 2019b), 85 cfs is modeled in July and August in all water year types (Table 38). For this analysis, it was unclear if Reclamation’s modeling results showing releases lower than 150 cfs in July and August was an inconsistency resulting from changes from an earlier version of the proposed action, or if it was a result of competing objectives for CalSimII model inputs. Reclamation clarified that the proposed action is 150 cfs in July and August (Harrison 2019b), but is not simulated in the model. Therefore, the assumption for this analysis is that the proposed action is what will occur, and the values in the model for these months are an underestimate, and in error. Under current operations, Clear Creek releases in July and August from 2000 to 2018 have generally been lower than 150 cfs in most years to conserve cold water pool in Whiskeytown Reservoir for fall water temperature management, except in 2014 and 2015 when base flows higher than 150 cfs were needed to meet water temperature requirements (Figure 65).

In Critical water year types, the proposed minimum instream base flows was not quantified. CalSimII modeling results (Table 38) indicate releases would be approximately 40 to 75 cfs less than proposed base flows. In Critical water year types, the minimum flow releases could be as low 50 cfs from January 1 to October 31, and 70 cfs November-December as specified in the memorandum of agreement under the 1960 minimum flow requirements (amended in 2000 under the Instream Flow Preservation Agreement by and among Reclamation, FWS and DFW, August 11, 2000), and under the April 15, 2002 State Water Resource Control Board permit. NMFS assumes flows specified in the memorandum of agreement would be the lowest minimum instream base flow releases that would occur in Critical water year types.While the ten thousand acre-feet for channel maintenance pulse flows proposed to occur from January through April were not modeled, discussions with Reclamation clarified that this volume of water would not change model outputs significantly (Harrison 2019a). Reclamation proposed ramping rates of 15 to 25 cfs per hour. This range would decrease stranding risks to juvenile salmonids, and fit within the precision of the constraints of the operation of the outlets.

Table 38. Monthly CalSimII outputs for Clear Creek at Igo for the proposed action for all water year-types based on the Sacramento Valley Index.

	Monthly Flow (CFS)											
Statistic	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Probability of Exceedance												
10%	200	200	200	200	200	200	200	277	200	85	85	150
20%	200	200	200	200	200	200	200	277	200	85	85	150
30%	200	200	200	200	200	200	200	277	200	85	85	150
40%	200	200	200	200	200	200	200	277	200	85	85	150
50%	200	200	200	200	200	200	200	277	200	85	85	150
60%	200	200	200	200	200	200	200	277	200	85	85	150
70%	200	200	200	200	200	200	200	277	200	85	85	150
80%	200	200	200	200	200	200	200	277	150	85	85	150
90%	150	150	150	150	150	150	150	237	150	85	85	150
Long Term												
Full Simulation Period[a]	187	188	190	225	207	194	191	265	181	85	86	148
Water Year Types[b,c]												
Wet (32%)	200	200	200	309	249	207	200	277	200	85	85	150
Above Normal (16%)	200	200	200	192	196	196	196	277	200	85	85	150
Below Normal (13%)	195	195	195	195	195	195	195	274	191	85	85	150
Dry (24%)	188	188	188	190	190	190	190	267	183	85	85	150
Critical (15%)	133	141	154	167	167	167	167	214	111	85	94	133

[a] *Based on the 82-year CalSimII simulation period.*
[b] *As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (State Water Resources Control Board 1999).*
[c] *These results are displayed with calendar year - year type sorting.*

Source: ROC on LTO biological assessment, Appendix D, Attachment 3-2, Table 14-2

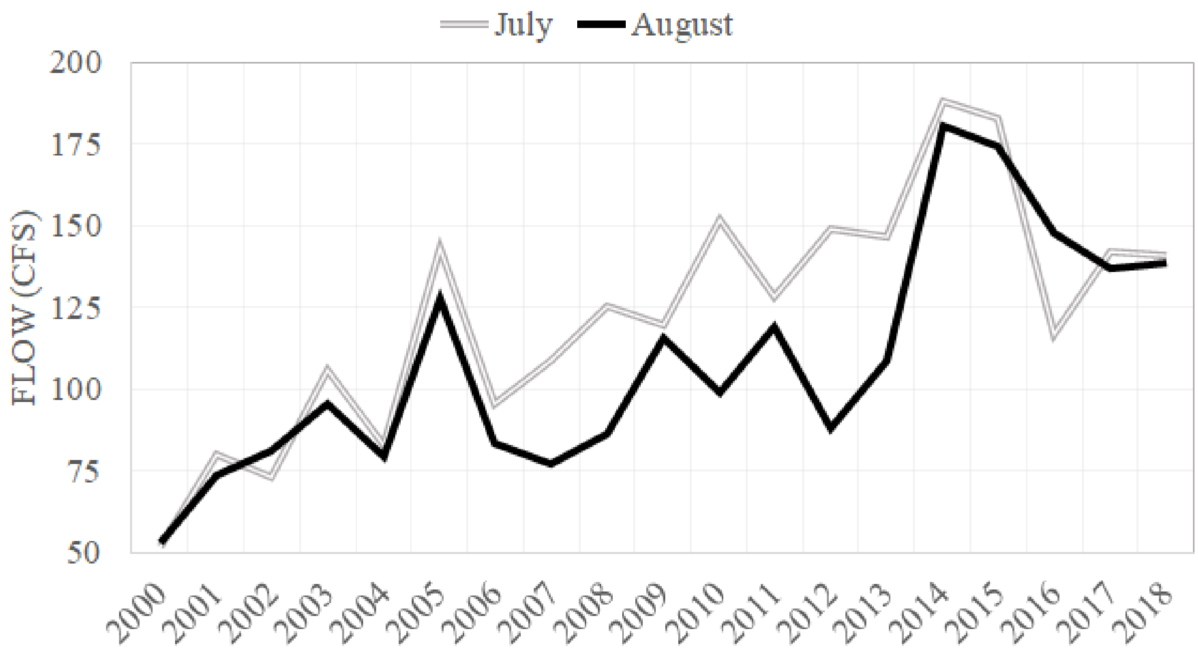


Figure 65. Mean monthly flows (cubic feet per second (cfs)) in July and August at the Igo gauging station (river mile 11.0) from 2000-18, Clear Creek, California. Data

Source: SacPAS: Central Valley Prediction & Assessment of Salmon website (University of Washington Columbia Basin Research 2019).

8.4.4.3 Minimum Instream Base Flows

Under the proposed action, minimum instream base flows are 200 cfs from October through May, and 150 cfs from June through September. Increased minimum flows of 150 cfs were first provided in the fall of 1995 for adult fall-run Chinook salmon (Brown 1996) and were based on recommendations for salmon and steelhead summarized in the Clear Creek Fishery study (Department of Water Resources 1986; Newton and Brown 2004). This flow schedule was incorporated into the CVPIA Anadromous Fisheries Restoration Program:

> *Release 200 cfs October 1 to June 1 from Whiskeytown Dam for spring-, fall-, and late fall-run chinook salmon spawning, egg incubation, emigration, gravel restoration, spring flushing and channel maintenance; release 150 cfs, or less, from July through September to maintain 60°F temperatures in stream sections utilized by spring-run Chinook salmon (U.S. Fish and Wildlife Service 2001).*

Reclamation has integrated temperature control and minimum base flow requirements into operations since 1995, which initially led to increased returns of fall-run Chinook salmon. During the summer of 1999, Reclamation first made releases from Whiskeytown Dam to support juvenile steelhead rearing downstream of Saeltzer Dam (prior to its removal in 2000), and increased releases in the fall to reduce water temperatures for CV spring-run Chinook salmon spawning. The proposed minimum instream base flows are the same as what were established in the NMFS 2009 Opinion, and therefore current operating scenario CalSimII modeling outputs and water flow under current operations are expected to be similar under the proposed action.

8.4.4.3.1 Central Valley Spring-run Chinook Salmon Exposure, Response, and Risk

Adult CV spring-run Chinook salmon migration into Clear Creek continues during the summer base flow period, with very low rates of passage in July and August (Figure 66). From 2013 to 2016, approximately 35 percent of CV spring-run Chinook salmon passage occurred in June, which also coincided with spring attraction pulse flows that occurred in each year. Lowering base flows from 200 cfs to 150 cfs on June 1 would likely create a passage impediment at the confluence due to warm water temperatures, and result in decreased adult migration rates and lower returns of CV spring-run Chinook salmon to Clear Creek.

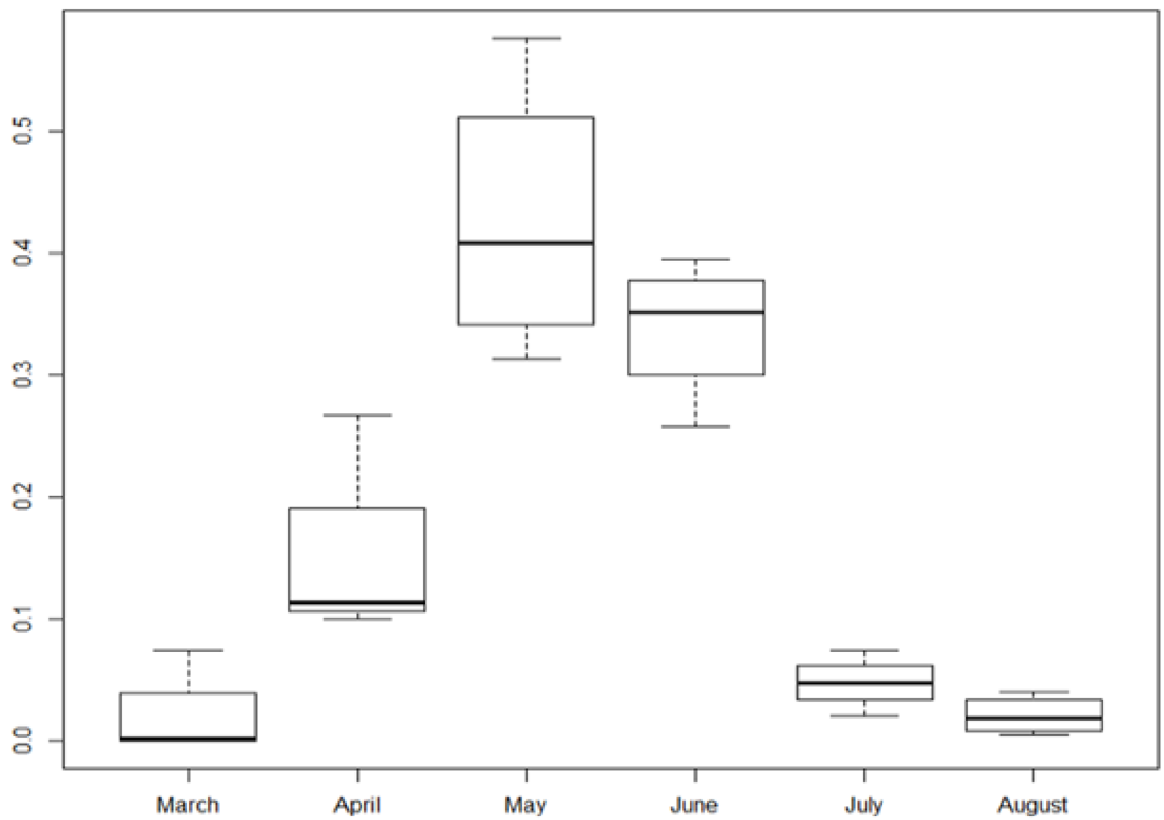


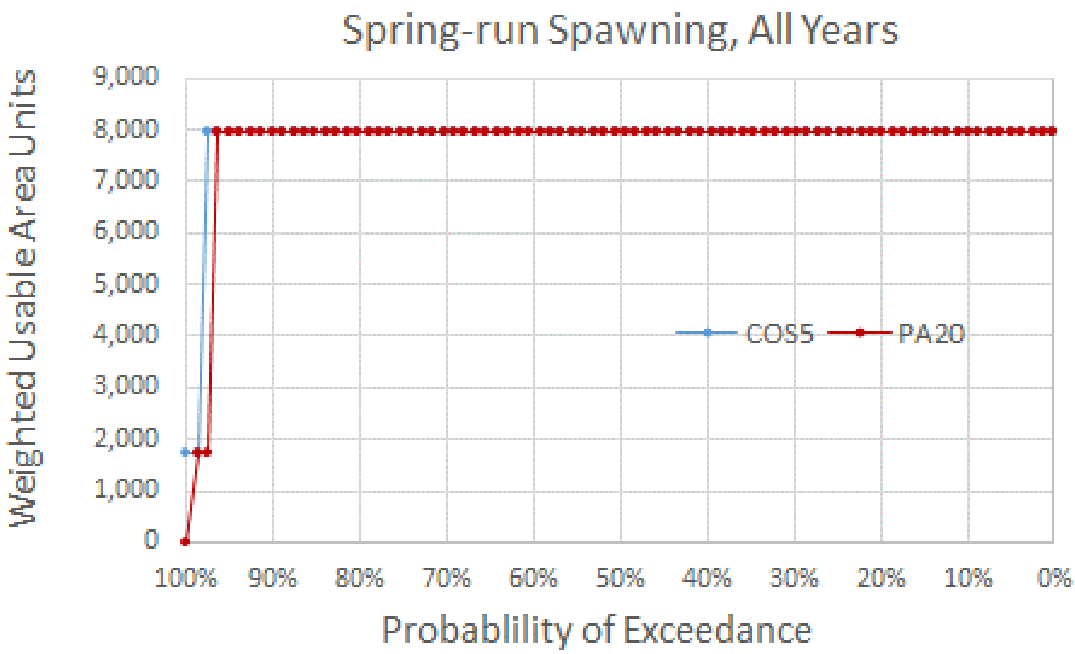
Figure 66. Proportion of annual Central Valley spring-run Chinook salmon passage by month at the Clear Creek Video Station from 2013 to 2016.

Source: (Clear Creek Technical Team 2018)

The low rate of migration 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 summer base 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.

The FWS has (1) developed rearing and spawning flow-habitat relationship curves for CV spring-run Chinook salmon, CCV steelhead, and fall-run Chinook salmon for Clear Creek; (2) compared habitat available to habitat needed to support population recovery; and (3) provided recommendations for creek flows and habitat needs for a range of population sizes (U.S. Fish and Wildlife Service 2015a). Weighted usable area 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 weighted usable area available under the proposed action, Reclamation performed modeled runs using flow-habitat relationship curves with mean monthly CalSimII flow estimates (Unger 2019). Differences in spawning and rearing weighted usable area in the modeled scenarios and exceedance curves were similar for the proposed action and current operating scenario minimum instream base flows in all water year types. When comparing the proposed action weighted usable area values to flow-habitat relationships in (U.S. Fish and Wildlife Service 2015a), the proposed minimum flows provided adequate rearing habitat for fry and juveniles, but not enough spawning habitat (Figure 67). Low estimates of spawning weighted usable area in the modeled runs are likely due to the use of outdated weighted usable area curves. New weighted usable area curves were developed after gravel supplementation projects increased available spawning habitat in Clear Creek (U.S. Fish and Wildlife Service 2015a). Under the updated curves, the proposed flows provide 50,000-60,000 sq. ft. of weighted usable area (Figure 67).



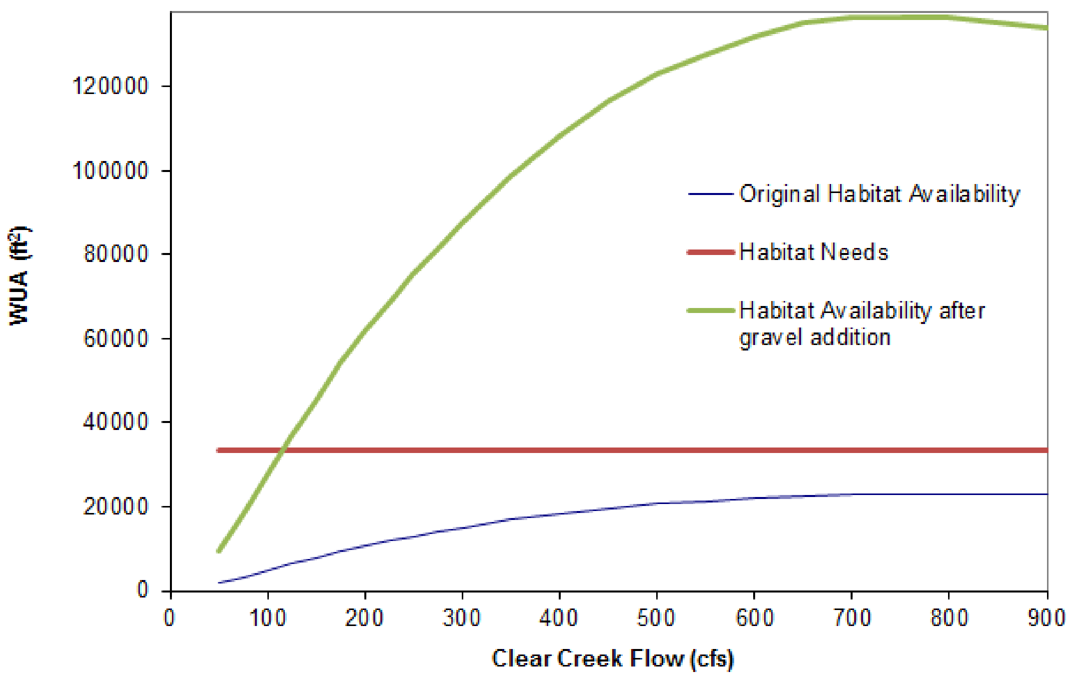


Figure 67. Top graph is the weighted usable area modeling results for CV spring-run Chinook salmon spawning habitat in Clear Creek under the proposed action (PA20) (Unger 2019) and current operation scenario (current operating scenario5). Bottom graph is the U.S. Fish and Wildlife Service (2015a) weighted usable area curve developed to include the increased spawning habitat availability after gravel addition projects.

In most years under the proposed action, base flows in Clear Creek will need to be greater than 150 cfs after September 15 to provide equal or less than 56°F daily average water temperatures, based on what has occurred under current operations. Under the proposed action, base flows increase to 200 cfs no later than October 1. In Critical year types, base flows may be reduced and 56°F daily average water temperature may not be achievable, thereby decreasing the amount of available spawning habitat for CV spring-run Chinook salmon. While the weighted usable area analysis does not indicate that spawning habitat is limited given the proposed base flows and current population levels, higher flows generally improve water temperatures for incubating eggs, and increase available spawning habitat. Increased suitable spawning habitat improves reproductive success, especially when larger populations of spawning CV spring-run Chinook salmon are present in Clear Creek.

Under the proposed action, flow releases would be increased from 150 cfs to 200 cfs during the period from October to May. In Critical water years, releases would be stabilized at 150 cfs from October to May. With the temperature management target changing from 60°F to 56°F on September 15, releases above 150 cfs may be made prior to October 1 to improve temperature management. Releases above 200 cfs may also be made to improve temperature management. Flow reductions to return to 200 cfs has the potential to result in redd dewatering and juvenile stranding. The magnitude of flow change, and therefore, effect, would depend on flows required to meet spawning temperatures in a given year.

In an evaluation estimating fall-run Chinook salmon redd dewatering rates in Clear Creek, flow decreases from 275 cfs to 200 cfs dewatered 6.1 percent of redds; 275 cfs to 150 cfs dewatered 29 percent of redds; and 200 cfs to 150 cfs dewatered 11 percent of redds (U.S. Fish and Wildlife Service 2015a). This information suggests dewatering of CV spring-run Chinook redds may occur during flow reductions under the proposed action. Based on CV spring-run Chinook salmon fry emergence timing in Clear Creek (i.e., mid-November to early February), flow in November and December would affect a high proportion of redds, though a small percentage may become dewatered.

Past monitoring indicated steady base flows, together with reduced occurrence and magnitude of channel forming flows, have resulted in the stabilization of gravel bars, riparian vegetation encroachment, and decreased habitat complexity in Clear Creek (Graham Matthews & Associates 2011; McBain and Trush 2001). The proposed action base flows provide an adequate amount of suitable habitat based on weighted usable area and the proposed action provides some flow variability to improve connectivity and channel processes. This flow variability improves habitat, creates migration cues, and improves downstream passage (see Section 8.4.4.4 below regarding Spring Attraction Pulse Flows).

8.4.4.3.2 California Central Valley Steelhead Exposure, Response, and Risk

Under the proposed action component, base flows provide adequate spawning and juvenile rearing habitat for CCV steelhead, based on weighted usable area results (Figure 68) and habitat needs identified in (U.S. Fish and Wildlife Service 2015a). This also includes Critical water year types (15 percent of years) when Reclamation will potentially operate to base flows approximately 50 cfs less than those of other water year types from October to June (Table 38).

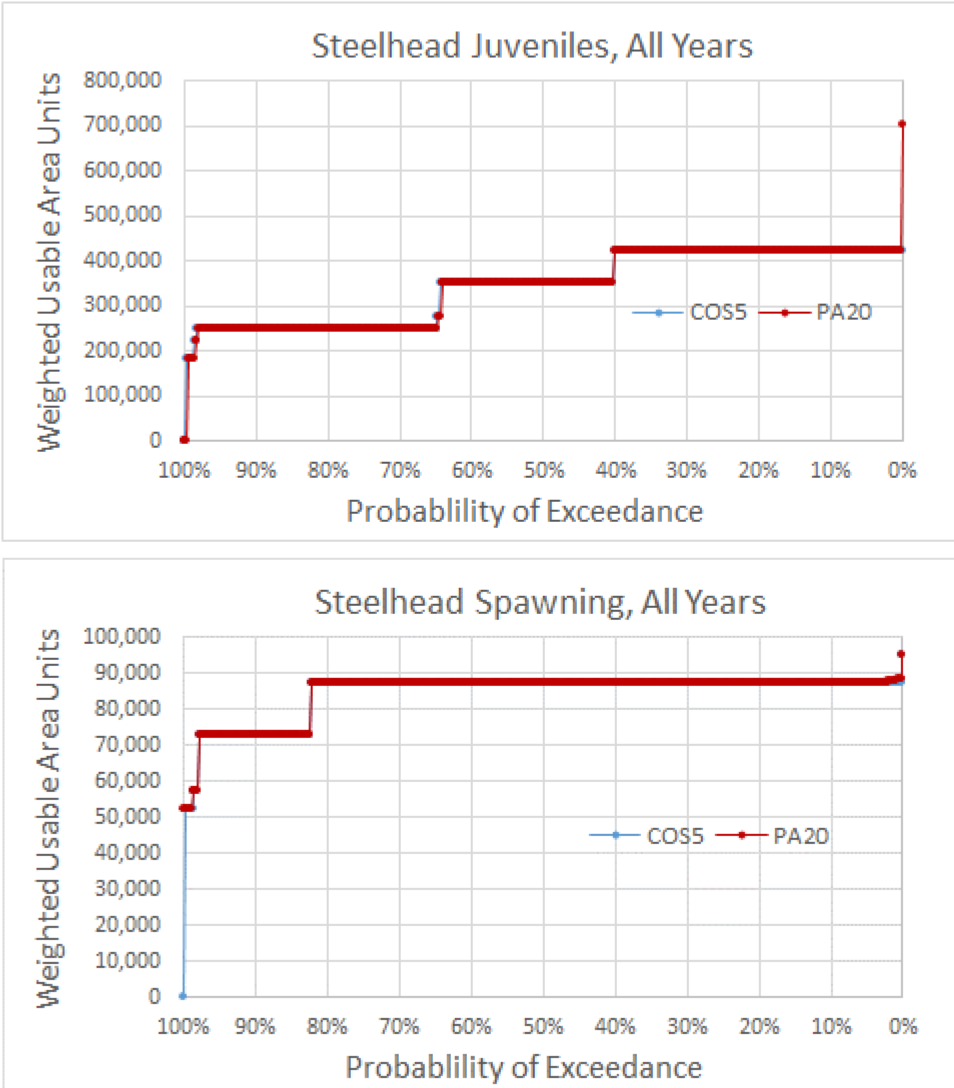


Figure 68. Weighted usable area modeling results for California Central Valley steelhead juvenile rearing (top) and spawning habitat (bottom) in Clear Creek under the proposed action (PA20) and current operation scenario (current operating scenario5).

Source: Unger (2019)

While the weighted usable area results show adequate habitat, increased water temperatures associated with lowered base flows in Critical water year types and warm air temperatures in the summer may reduce the actual amount of rearing habitat available in the lower watershed. Daily average water temperatures can range from 65°F to 70°F in July and August in the most downstream three miles of the creek, which may restrict the total available habitat for rearing (Figure 61).

In Critical water year types (15 percent of years), base flows may be reduced to approximately 150 cfs during CCV steelhead spawning, and redds may be susceptible to dewatering and egg mortality, depending on when flow decreases occur. Water year type forecasting begins February and type is determined in May. In addition, under current operations, flows greater than 200 cfs have been needed to meet water temperature criterion for CV spring-run Chinook salmon egg incubation though October 31. In those years, flow reductions back to 200 cfs (or less in Critical water year types) that occur after the onset of CCV steelhead spawning in mid-December would expose redds to dewatering. Any flow reductions from mid-December through April would expose a large portion of CCV steelhead redds to dewatering. In an evaluation estimating fall-run Chinook salmon redd dewatering rates in Clear Creek, flow decreases from 275 cfs to 200 cfs dewatered 6.1 percent of redds; 200 cfs to 150 cfs dewatered 11 percent of redds; and 275 cfs to 150 cfs dewatered 29 percent of redds (U.S. Fish and Wildlife Service 2015a). This information suggests dewatering of CCV steelhead redds may occur during flow reductions under the proposed action. The proportion of CCV steelhead redds dewatered would likely more variable than fall-run Chinook salmon, due to the longer spawning season, and depending on when flow decreases occur. Based on redd dewatering rates, and the low occurrence of Critical water year types, a small amount of reduced egg-to-fry survival of CCV steelhead is expected during minimum base flow decreases.

Past monitoring indicated steady base flows, together with reduced occurrence and magnitude of channel forming flows, have resulted in the stabilization of gravel bars, riparian vegetation encroachment, and decreased habitat complexity in Clear Creek (Graham Matthews & Associates 2011; McBain and Trush 2001). The proposed action base flows provide an adequate amount of suitable habitat based on weighted usable area and the proposed action provides some flow variability to improve connectivity and channel processes. This flow variability improves habitat, creates migration cues, and improves downstream passage (see Section 8.4.4.4 below regarding Spring Attraction Pulse Flows).

8.4.4.4 Spring Attraction Pulse Flows

Reclamation is proposing to allocate 10 thousand acre-feet to create spring attraction pulse flows, with a daily release up to the safe release capacity (approximately 900 cfs, depending on reservoir elevation and downstream capacity). For spring attraction flows, Reclamation would release 10 TAF (measured at the release), with daily release up to the safe release capacity (approximately 900 cfs, depending on reservoir elevation and downstream capacity), in all year-types except for Critical year-types to be shaped by the Clear Creek Implementation Team in coordination with Reclamation. The goal of spring attraction flows is to create hydrologic, temperature, and turbidity cues to encourage adult CV spring-run Chinook salmon to 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. Proposed spring attraction pulse flows may reduce stressors related to water operations by improving water flow and water temperature, and increase passage over impediments and improving natural river morphology and function.

Spring attraction pulse flows have been implemented since 2010, and timed to coincide with the CV spring-run Chinook salmon migration period. The Clear Creek Technical team has developed the pulse flow schedule annually using an adaptive approach, by varying the timing, magnitude, and duration of releases based on monitoring results (e.g., Clear Creek Technical Team 2016). Attraction flows are intended to mimic natural hydrologic cues, which include cooler water temperatures and increased turbidity. In years when the adult CV spring-run Chinook salmon population size is large enough to detect, snorkel survey and video monitoring data have shown that pulse flow releases have been successful (Chamberlain 2019a).

8.4.4.4.1 Spring-run Chinook Salmon Exposure, Response, and Risk

The proposed spring attraction pulse flows are intended to encourage entry to Clear Creek by coinciding 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. Increased flow releases of this magnitude 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, creating turbidity, and increasing passage routes. Improved passage and migratory cues would 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.

Spring attraction pulse flows have been implemented on Clear Creek annually since 2010, and monitoring has indicated some success. Pulse flows events have increased turbidity, decreased water temperatures, and 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 2016; Clear Creek Technical Team 2018). Monitoring data has shown that a change in distribution upstream of holding CV spring-run Chinook salmon in Clear Creek before and after pulse flows has occurred less frequently (Clear Creek Technical Team 2019). Due to the nature of CV spring-run Chinook salmon in Clear Creek, individuals that migrate in during the pulse flows may stage and hold in the lower reaches rather than migrating upstream, and be susceptible to negative effects from warmer water and introgression with fall-run. Continued implementation of spring attraction flows in the proposed action in June is expected to provide increased opportunity for adult passage during the lower base flow period.

Spring attraction pulse flows would not occur during CV spring-run Chinook salmon spawning and egg incubation, and therefore, this life stage would not be exposed to the effects of the pulse flows. 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. 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.

Spring attraction pulse flows are expected to benefit juvenile CV spring-run Chinook salmon by improving downstream passage. Pulse flows increase turbidity and velocity, cool water temperatures, and create cues for outmigration. Improved outmigration conditions is 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 food availability and growth rates. Spring attraction pulse flows may also displace juveniles downstream into warmer water habitat, which may increase risk of predation, disease, and mortality. During spring attraction pulse flow ramp down, juveniles may also become stranded and isolated from the creek, and succumb to predation or desiccation. Down-ramping rates will be implemented, which will reduce stranding risk and minimize negative impacts on survival from flow decreases. A low proportion of juveniles are still expected to become stranded or isolated.

Each year during spring attraction pulse flows, we expect benefits to a low proportion of juveniles expected to outmigrate, decreased survival to a low proportion of displaced juveniles that remain in the lower reaches, and decreased survival of a low proportion of juveniles subject to stranding.

8.4.4.4.2 California Central Valley Steelhead Exposure, Response, and Risk

Some CCV steelhead eggs would still be incubating from April through June. Because approximately 90 percent of the annual CCV steelhead redd count occurs by mid-February (Schaefer et al. 2019), a small proportion of the redds would be exposed to fine sediment infiltration, increasing the risk of mortality of incubating eggs. 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. Juvenile CCV steelhead rear in fresh water from 1 to 3 years. Spring attraction pulse flows occur during a time when smolts have been observed outmigrating in Clear Creek. Exposure to pulse flows would give CCV steelhead access to temporary rearing habitat within side channels, potentially increasing food availability resulting in increased growth rates. Increased flows and turbidity and cooler water temperatures create migration cues, improve downstream passage conditions, reduce predation, and increase survival of smolts. Available rearing habitat (weighted usable area) for juvenile CCV steelhead increases from approximately 200,000 sq ft. at base flows to 700,000 sq ft when flows are nearing 900 cfs (U.S. Fish and Wildlife Service 2015a). Though short lived, the pulses may provide opportunity for new food sources, and improved growth and survival. Conversely, juvenile CCV steelhead may be displaced downstream during attraction pulse flows and after flows decrease, remain in unsuitable habitat, which would likely be warmer and at risk of increased predation, disease, and mortality. During spring attraction pulse flow ramp down, juveniles may also become stranded and isolated from the creek, and succumb to predation or desiccation. Down-ramping rates will be implemented, which will reduce stranding risk and minimize negative impacts on survival from flow decreases. However, a low proportion of juveniles are still expected to become stranded or isolated. Therefore, we expect increased survival and fitness of a high proportion of CCV steelhead rearing juveniles and outmigrating smolts, in addition to decreased survival to a low proportion of juveniles that remain in the lower reaches after spring-pulse flows. A small proportion of juveniles would also be subject to stranding during the pulse flows.

8.4.4.5 Channel Maintenance Pulse Flows

Reclamation is proposing to allocate 10 thousand acre-feet channel maintenance pulse flows each water year, up to the safe release capacity (approximately 900 cfs, depending on reservoir elevation and downstream capacity), except in Dry (24 percent) and Critical (15 percent) water year types. Reclamation will reduce the volume and occurrence of the proposed channel maintenance pulse flows if storm events create natural spills through the Whiskeytown Glory Hole of sufficient duration and magnitude, which include (1) for each storm event that results in a spill of at least 3,000 cfs for 3 days, channel maintenance flow volume for that year or the following year will be reduced by 5,000 acre-feet, and (2) if two spills of at least 3,000 cfs for 3 days each occur, additional channel maintenance pulse flows would not be released that year.

Each new water year, channel maintenance pulse flows would not occur until after January 1, such that Reclamation would have enough information to make initial assessments and assumptions of water year type and available storage, and determine what restrictions on occurrence and amount of water may be needed for planning the flows. Given the parameters identified in the proposed action, NMFS expects that one to four channel maintenance pulse flows would occur from January through April. To maximize the magnitude of the flow and thereby the geomorphic benefit, NMFS also assumes that flows would be scheduled to occur during natural rain events.

The goal of the proposed action channel maintenance flows is to provide high flow events that will benefit geomorphic processes in the channel and improve salmonid habitat for spawning and rearing. While the magnitude is significantly less than the 3,000-4,000 cfs recommended for sediment transport and floodplain inundation, and the 4,000-6,000 cfs for channel formation (U.S. Bureau of Reclamation and ESSA Technologies Ltd 2008), flows would provide some benefit to sediment transport and improving salmonid habitat. In an evaluation of sediment transport in Clear Creek, Graham Matthews & Associates (2013) findings showed that recent spring attraction pulse flows near 1,000 cfs mobilized supplemental spawning gravel (injection gravel), and have had some value for channel maintenance.

Whiskeytown Dam blocks coarse sediment transport, and average annual peak flows and flooding frequency have been reduced downstream of the dam. All but the highest flows that pass as a spill were eliminated. This has led to channel simplification, riparian encroachment, and loss of quality and quantity spawning habitat. High flows are important to form and maintain channel and floodplain morphologies, maintain connectivity, and necessary to sustain previous and current restoration activities, including spawning gravel routing. Injection gravel has been added annually to Clear Creek since 1996 (totaling approximately 176,000 tons) and is dependent on high creek flows for transport downstream. Peak flows resulting from tributary run-off have little effect in the upper 2 miles of the creek so flow releases from Whiskeytown Dam are especially important in this section for injection gravel mobilization (Graham Matthews & Associates 2011).

The 2004 Environmental Water Program (EWP) proposal set release targets based on sediment transport modeling, and bed mobility studies that suggested flow magnitudes should range from 4,000 to 6,000 cfs, over two days, at a rate of 3 per 10 years based on the 40-year historical dataset of inflow upstream of the reservoir (U.S. Bureau of Reclamation and ESSA Technologies Ltd 2008). Upon further evaluation, it was determined that 3,250 cfs could also provide significant geomorphic benefit, and this target discharge was used to evaluate the feasibility of the implementation of the reoperation of Whiskeytown Dam to provide flood flows to Clear Creek through the Glory Hole (U.S. Bureau of Reclamation and ESSA Technologies Ltd 2008).

To determine the frequency of occurrence of the proposed action channel maintenance flows, NMFS used historic records of Glory Hole spills, and Reclamation’s model results for the proportion of Dry and Critical water year types that would occur under the proposed action. Channel maintenance pulse flows would not occur in approximately 40 percent of years, based on the frequency of occurrence of Dry (24 percent) and Critical (15 percent) water year types. From 1965-2005, there were 13 Glory Hole flow spill events that occurred above 3,250 cfs or greater for one day or more, with gaps of up to 12 years apart (U.S. Bureau of Reclamation and ESSA Technologies Ltd 2008). Based on the historical record, Glory Hole spills of magnitude that would reduce the need for channel maintenance pulse flows would occur in approximately 30 percent of years under the proposed action. Scheduled channel maintenance pulse flow releases through the outlet would likely occur in approximately 30 percent of years. Therefore, NMFS expects that scheduled channel maintenance pulse flows would occur between 30 to 60 percent of years, depending on the number of spills that occur through the Glory Hole spillway.

8.4.4.5.1 Central Valley Spring-run Chinook Salmon Exposure, Response, and Risk

Based on migration timing data, less than 10 percent of the returning adult CV spring-run Chinook salmon population will be present in Clear Creek during channel maintenance pulse flows and, therefore, exposed to its conditions. High flow and turbidity conditions associated with channel maintenance pulse flows may attract migrating adult CV spring-run Chinook salmon into Clear Creek, if releases occur in March or April. 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.

Channel maintenance pulse flows are expected 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 through early February. 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. 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 January 1, and therefore a low proportion are expected to result in mortality in years when channel maintenance pulse flows occur (approximately every 3-6 years; 1-2 times per year).

The majority of juvenile CV spring-run Chinook salmon emigrate by February. Depending on the timing of channel maintenance pulse flows, a low to medium portion of the rearing juveniles are expected to be present. Channel maintenance pulse flows may displace juveniles, make them susceptible to isolation and stranding following down-ramping, and cause mortality. Down-ramping rates will be implemented, which will reduce stranding risk and minimize negative impacts on survival from flow decreases. However, a low proportion of juveniles are still expected to become stranded or isolated. High flow releases are expected to benefit juveniles by providing temporary access to additional rearing habitat that provides shelter and access to food, increasing growth and survival. While juvenile CV spring-run Chinook salmon rearing habitat is not limited based on habitat suitability results, at this time of the year, juvenile fall-run Chinook salmon are also present in much larger numbers and compete for rearing habitat. Flows of the proposed magnitude also provide outmigration cues, increased passage routes, and increased protection from predators due to increased turbidity. While the portion of rearing juvenile CV spring-run Chinook salmon is low to medium in years when channel maintenance pulse flows occur (approximately every 3-6 years; 1-4 times per year), channel maintenance flows are expected to provide benefits to rearing and outmigrating juveniles. Additional long term expected benefits of this action to CV spring-run Chinook salmon include increased survival of eggs, and increased production due to improved spawning habitat.

8.4.4.5.2 California Central Valley Steelhead Exposure, Response, and Risk

Given the timing of the channel maintenance pulse flows contemporaneous with peak storm flows from January through April, and life history of CCV steelhead in Clear Creek, all life stages and the majority of the overall population, including migrating adults, incubating eggs in redds, and rearing and out-migrating juveniles would be exposed to the effects of channel maintenance pulse flows.

Channel maintenance pulses flows would occur during adult CCV steelhead migration and spawning. Because the timing of CCV steelhead migration occurs over a long period, from mid-December through April, and timing may be variable based on in-river conditions, the proportion of passage that occurs after January 1 is variable annually. Based on 5 years of preliminary video monitoring passage data at the mouth of Clear Creek, 24-88 percent (average 46 percent) of steelhead migrate into Clear Creek by January 1. Based on the variability on the timing, frequency and magnitude of channel maintenance pulse flows annually (approximately every 3-6 years; 1-4 times per year), and the range of migration timing, effects to the species migration would be variable each year. For the migration life stage of CCV steelhead, channel maintenance pulse flows would be beneficial, creating cues to encourage migration from the Sacramento River and improve migration conditions by creating more passage routes. Pulse flows would likely help to increase overall population size in Clear Creek.

Channel maintenance pulse flows are expected to improve spawning habitat by mobilizing and dispersing gravel, and reducing fine sediment. CCV steelhead egg incubation occurs from mid-December through June, with peak spawning in January. Redds are located throughout the creek, with the majority distributed downstream of river mile 6. Based on spawn timing, the majority of CCV steelhead redds would be exposed to channel maintenance pulse flows, and subject to infiltration of fines that cause mortality to incubating eggs. The proposed channel maintenance flows (unless coupled with storm events) are low enough in magnitude they are not likely to cause high rates of redd scour. CCV steelhead may also choose spawning locations at the higher flows, and redds may be dewatered after flow releases are decreased. However, flows of this magnitude normally occurs during CCV steelhead spawning, when winter storms would likely increase creek flows, and therefore the impacts of the channel maintenance pulse flows would not be that different from natural flows.

Emergent CCV steelhead fry are first observed in the rotary screw traps beginning in mid-January. Juvenile CCV steelhead rear in fresh water from 1 to 3 years, and therefore multiple year classes are present and distributed throughout Clear Creek year round, which includes channel maintenance pulse flow period.

Exposure to channel maintenance pulse flows would give CCV steelhead access to temporary rearing habitat within floodplains and side channels, potentially increasing food availability, resulting in increased growth rates. Flows of the proposed magnitude also provide outmigration cues, increased passage routes, and increased protection from predators due to increased turbidity. Available rearing habitat (weighted usable area) for juvenile CCV steelhead increases from approximately 200,000 sq ft. at base flows to 700,000 sq ft when flows are nearing 900 cfs (U.S. Fish and Wildlife Service 2015a). Though short lived, the channel maintenance pulse flows would allow for some overbank flow to temporarily create side channel and (and potentially floodplain connectivity if releases are coupled with storm flows) and support juvenile growth and survival.

A large proportion of juveniles would be susceptible to stranding and isolation from the creek during down-ramping. However, down-ramping rates will be implemented that reduce stranding risk and minimize negative impacts on survival from flow decreases. A low proportion of juveniles are still expected to become stranded or isolated. The proportion of rearing juvenile CCV steelhead between January and April is high, and in years when they occur (approximately every 3-6 years; 1-4 times per year), channel maintenance flows are expected to provide benefits to rearing juveniles and outmigrating smolts. Additional long term expected benefits of this action to CCV steelhead include increased survival of eggs, and increased production due to improved spawning habitat.

8.4.5 Division Effects Summary

The following tables summarize the project-related stressors for each species and component of the proposed action. The 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.

8.4.5.1 CV Spring-Run Chinook salmon

Central Valley spring-run Chinook salmon juvenile, and adults will be affected by the proposed action (Table 39 and Table 40)

Table 39. Summary of Trinity River Division operation-related effects on juvenile Central Valley spring-run Chinook salmon.

Action Component	Stressor/ Factor	Individual Response and Rationale of Effect	Severity of Stressor/Level of Benefit	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness
Spring pulse flows on Clear Creek	Water flow	Increased flows create migration cues and improve downstream passage by decreasing water temperatures, increasing turbidity. Provide temporary access to additional rearing habitat.	Beneficial: Medium	Medium	High	Medium to	Medium	Increased growth. Improved survival. Increased life history diversity.
Water temperature management: Summer	Water temperature	Temperatures may be above optimal growth and survival >65°F. Increased stress, risk of predation and disease.	Minor	Small	High	Low	Medium	not expected to create long-term harm to the fish, or result in injuries leading to mortality

Table 40. Summary of Trinity River Division operation-related effects on adult Central Valley spring-run Chinook salmon.

Action Component	Stressor/ Factor	Individual Response and Rationale of Effect	Severity of Stressor/Level of Benefit	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness
Channel maintenance pulse flows	Water flow, Loss of Natural River Morphology and Function, Passage Impediments/Barriers	Increased flows create migration cues by increasing turbidity, decreasing water temperatures, and improving passage of physical barriers to the most upstream reaches for holding.	Beneficial: Low	Small	Medium	Low	Medium	Increased survival. Increased reproductive success

Action Component	Stressor/ Factor	Individual Response and Rationale of Effect	Severity of Stressor/Level of Benefit	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness
Spring attraction pulse flows on Clear Creek	Adult Passage	Increased flows create migration cues by increasing turbidity, decreasing water temperatures, and improving passage of physical barriers to the most upstream reaches	Beneficial: Low-Medium	Large	High	Low to Medium	Medium	Increased survival. Increased reproductive success
Minimum instream base flows	Water flow; Passage Impediments	Low flow barriers at riffles and cascades may inhibit access to holding locations.	Minor	Medium	High	Medium	Low	Reduced spatial diversity (restricted spawning range)
Water temperature management: Summer	Water Temperature	Warm water temperatures >65°F may block or inhibit upstream migration	Minor	Small	High	Low	Medium	Reduced survival and reproductive success
Water temperature management: Summer	Water Temperature	Adults are exposed to >60°F, which may cause stress, disease, reduced fecundity, and prespawn mortality.	Sublethal	Medium	Medium	Medium	Medium	Reduced reproductive success.

8.4.5.2 California Central Valley Steelhead

CCV steelhead salmon eggs-to-fry, juvenile, and adults will be affected by the proposed action (Table 41, Table 42, and Table 43)

Table 41. Summary of Trinity River Division operation-related effects on California Central Valley steelhead eggs-to-fry.

Action Component	Stressor	Individual Response and Rationale of Effect	Severity of Stressor/Level of Benefit	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness
Minimum instream base flows	Water flow	Base flow reductions in Critical water year types, and/or after the fall water temperature management period ends, may dewater redds.	Sub-lethal to lethal	Medium	Low	Medium	Medium. IFIM reports on rates of dewatering following flow changes.	Reduced survival of eggs and alevins exposed to dewatering and reduced flow
Channel maintenance pulse flows	Water flow	transport sediment that can expose redds to infiltration of fine sediment or scour redds	Sub-lethal to Lethal	Large	Medium	Low	Low	Reduced survival.

Table 42. Summary of Trinity River Division operation-related effects on juvenile California Central Valley steelhead.

Action Component	Stressor	Individual Response and Rationale of Effect	Severity of Stressor/Level of Benefit	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness
Minimum instream base flows	Water flow	Static flow regime will continue to restrict access to rearing habitat and refugia, and reduce migratory cues.	Minor	Medium	High (annually)	Medium	Low	Continued reduced growth, survival consistent with current operations.
Spring attraction pulse flows	Water flow; Water temperatures; Passage Impediments/Barriers	Increased flows create migration cues and improve downstream passage by decreasing water temperatures, increasing turbidity. Provide temporary access to additional rearing habitat.	Beneficial: medium	Medium	High (annually)	Medium	Medium: Monitoring data shows juvenile movement during pulse flows.	Increased growth. Improved survival. Increased life history diversity.
Spring attraction pulse flows	Water flow	Flow decreases following pulse flows cause isolation and stranding. Down-ramping rates will reduce magnitude.	Sub-lethal	Medium	High (annually)	Low	Medium	Reduced survival.
Water temperature management: summer	Water Temperature	Less frequent Suboptimal temperatures (>61° F) cause a reduction in stress	Minor	Small	Medium	Low	Low	reduced growth, survival, slightly improved over current conditions

Action Component	Stressor	Individual Response and Rationale of Effect	Severity of Stressor/Level of Benefit	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness
Channel maintenance pulse flows	Water flow	Flow decreases following pulse flows may cause isolation and stranding, resulting in mortality. Down-ramping rates will reduce magnitude.	Lethal	Low	Medium	Medium	Medium.	Reduced survival for fish stranded
Channel maintenance pulse flows	Water flow	Pulse flows improve downstream passage by creating migration cues, increasing turbidity, and increasing passage routes. High flows provide temporary access to rearing habitat.	Beneficial: medium	Medium	Medium	Medium	Medium	Increased growth. Improved survival. Increased life history diversity.

Table 43. Summary of Trinity River Division operation-related effects on adult California Central Valley steelhead.

Action Component	Stressor	Individual Response and Rationale of Effect	Severity of Stressor/Level of Benefit	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness
Water temperature management: summer and fall	Water Temperature	Less frequent suboptimal water temperatures	Beneficial: medium	Medium	High	Medium	Medium	reduced pre-spawn mortality and higher egg survival
Channel maintenance pulse flows	Water flow	create migration cues, and increase turbidity and passage routes and improve spawning habitat by mobilizing gravel and reducing fine sediment.	Beneficial-medium	Medium	Medium	Medium	Medium	Improved survival. Increased life history diversity.

8.5 American River Division

NMFS deconstructed the proposed action to identify the project components (Figure 69) that would create stressors that may affect listed species (Table 44). The exposure, risk, and response of each species to the project-related stressors are then analyzed in the following sections for each proposed action component.

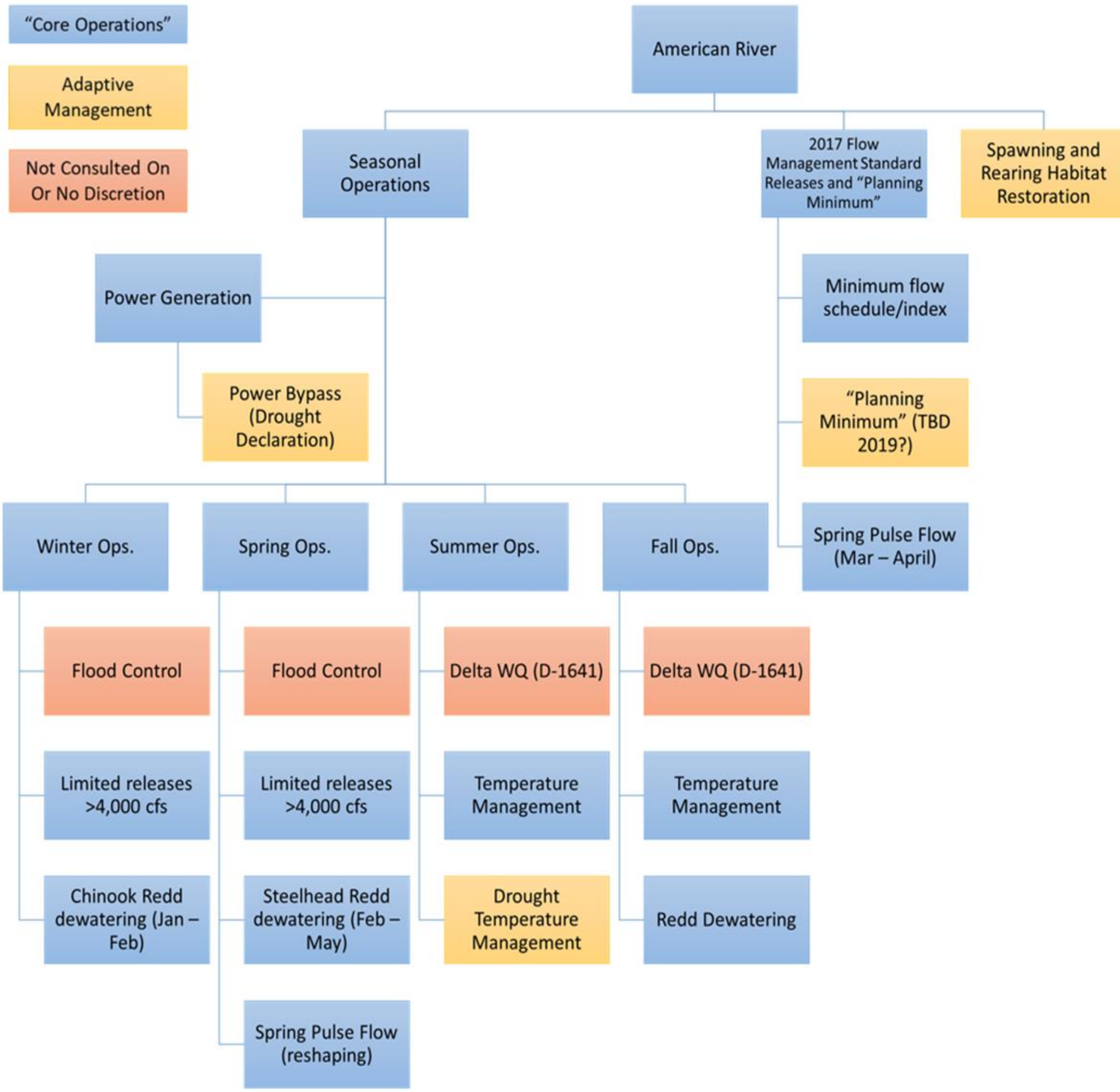


Figure 69. Deconstructed project components in the American Division.

Table 44. Stressors created by components of the proposed action in the American River Division.

Project Component	Water Temperature	Water Flow
Water Temperature Management	X	-
Flow Management	-	X
Conservation Measures	X	-

An "X" indicates that the action component affects a stressor category; the response could be negative or positive.

The only ESA-listed species that spawns within the American River is CCV steelhead. 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 which 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. Steelhead co-evolved with predators such as pikeminnow (*Ptychocheilus grandis*), but exposure to both elevated water temperatures and limited flow-dependent habitat availability resulting from CVP operations make juvenile steelhead more susceptible to predation (Bratovich et al. 2005; Water Forum 2005).

For the purposes of this analysis, "exposure" is defined as the temporal and spatial co-occurrence of a natural origin steelhead life stage and the stressors associated with the proposed action. A few steps are involved in assessing steelhead exposure. In the first step, the steelhead life stages and associated timings are identified. Adult 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 egg 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 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).

The second step in assessing steelhead exposure is to identify the spatial distribution of each life stage. The steelhead immigration life stage occurs throughout the entire lower American River with adults holding from approximately river mile five to Nimbus Dam at river mile 23 (Hannon and Deason 2008). Approximately 90 percent of spawning occurs upstream of the Watt Avenue Bridge area located at about 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 steelhead are believed to migrate through the lower sections of the American River into the Sacramento River as smolts.

The last step in assessing steelhead exposure is to overlay the temporal and spatial distributions of proposed action-related stressors on top of the temporal and spatial distributions of lower American River steelhead.

Now that the exposure of lower American River 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 mortality. Life stage-specific responses to specific stressors related to the proposed action are described in detail in the following sections.

There may be other project stressors acting on lower American River steelhead than those identified below. However, this effects analysis intends to identify and describe the most important project-related stressors to these fish. The stressors from the project components were identified based on a comprehensive literature review, which included the following documents:

- Lower American River State of the River Report (Water Forum 2005);
- Aquatic Resources of the Lower American River: Baseline Report (Surface Water Resources Inc. 2001);
- Impacts on the Lower American River Salmonids and Recommendations Associated with Folsom Reservoir Operations To Meet Delta Water Quality Objectives and Demands (Bratovich et al. 2005);
- American River Steelhead Spawning 2001 to 2007 (Hannon and Deason 2008);
- Steelhead Restoration and Management Plan for California (McEwan and Jackson 1996);
- Evaluation of Effects of Flow Fluctuations on the Anadromous Fish Populations in the Lower American River (Snider et al. 2001);
- Lower American River Biweekly Spawning and Stranding Surveys 2017 to 2018 (American River Group 2017; American River Group 2018);
- NMFS 2009 Opinion (National Marine Fisheries Service 2009b); and
- ROC on LTO biological assessment (U.S. Bureau of Reclamation 2019c)

8.5.1 Lower American River Water Temperature Management

Releases from Nimbus Dam to the American River affect the quantity and quality of steelhead habitat (Snider et al. 2001; Water Forum 2005), water quality, and water temperature (Kimmerer and Nobriga; State Water Resources Control Board 1999). Water temperature is perhaps the physical factor with the greatest influence on American River steelhead. Water temperature directly affects survival, growth rates, distribution, and developmental rates. Water temperature also indirectly affects growth rates, disease incidence, predation, and long-term survival (Myrick and Cech Jr 2001). Water temperatures in the lower American River are a function of the timing, volume, and temperature of water being released from Folsom and Nimbus dams, river distance, and environmental heat flux (Bartholow 2000). Thus, water temperatures in the lower American River are influenced by proposed action operations. Indirectly, 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. Reclamation proposes to target daily average water temperatures of 65°F or lower at Watt Avenue Bridge May 15 through October 31 of each year. When the target temperature requirement cannot be met because of limited coldwater 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. Reclamation also proposes to target daily average water temperature of 56°F from November 1 through December 31 each year if the cold water pool allows.

This analysis relies on both modeled water temperature results and recent water temperature data. As for other Division analyses, NMFS used modeled temperatures provided in the biological assessment to evaluate the suitability of water temperature conditions for salmonids under the proposed action. Recent water temperature data from the lower American River are used to provide context for temperature scenarios that steelhead could be exposed to under the proposed action. Recent water temperature data from the lower American River are assumed to be in the same general range water temperatures as those expected to occur under the proposed action, and may be a better indicator of the daily temperature patterns that steelhead will be exposed to under the proposed action than the modeled water temperature results, which have a monthly time-step.

8.5.1.1 Egg Incubation

Based on the thermal relationships reported above and the temporal distribution of steelhead egg incubation (i.e., late December through May), some level of egg mortality and/or reduced fitness of those individuals that survive is expected with exposure to the water temperatures that are expected to occur with implementation of the proposed action. For example, mean water temperatures at Watt Avenue from 1999 through 2018 ranged from about 48°F to over 55°F in March, 50°F to over 60°F in April, and 54°F to over 65°F in May (Figure 70).

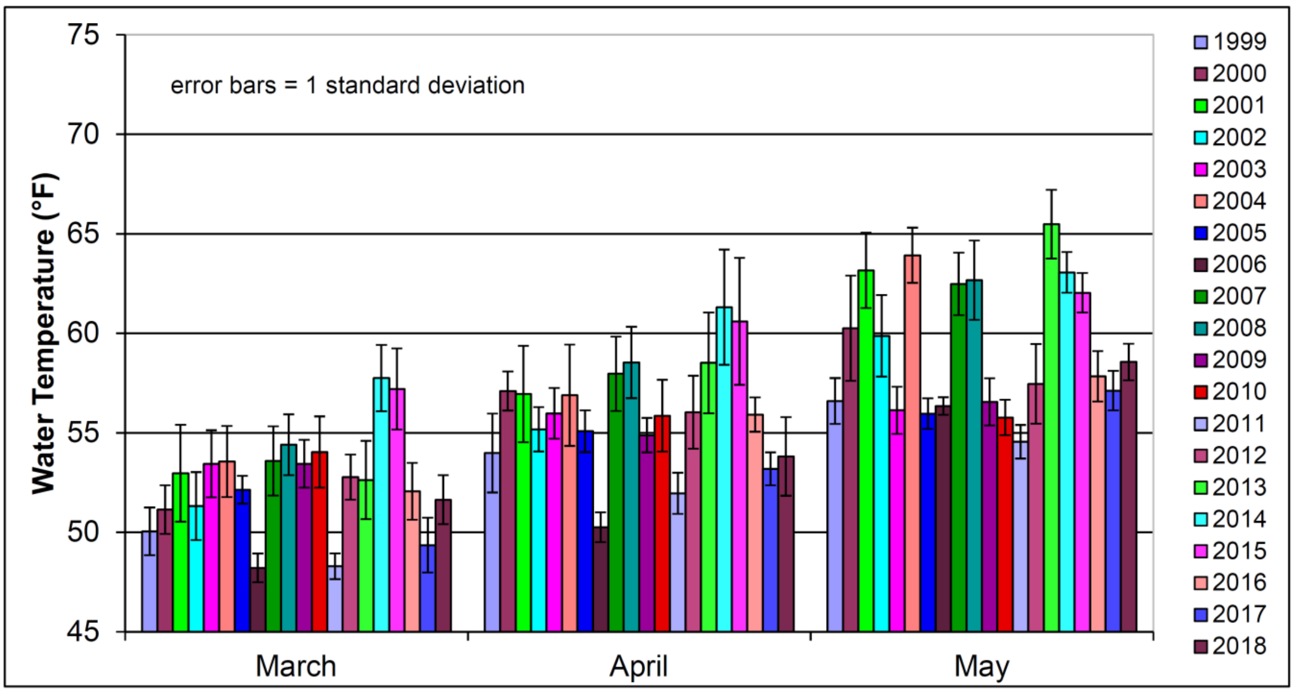


Figure 70. Lower American River water temperature during March, April, and May from 1999 through 2018 represented as the mean of the daily average at the Watt Avenue gauge.

Source: data were obtained from the CDEC website

These data indicate that steelhead egg mortality is expected to continue to occur for at least a proportion of the population in most years during April and May under the proposed action. Exceedance plots comparing water temperatures between current operations and the proposed action below Nimbus Dam show temperatures are expected to be over 54°F for about 60 and 100 percent of the cumulative water temperature distribution during April and May, respectively, under the proposed action. Water temperatures are expected to be above 57°F for about ten percent of the distribution in April and 70 percent in May (Figure 71 and Figure 72). The frequency of temperatures above 56°F has been reduced in the proposed action modeling as compared to the current operating scenario. During the warmest 20 percent of the cumulative water temperature distribution during May, water temperatures are expected to exceed 62°F in both the proposed action and current operating scenario modeling.

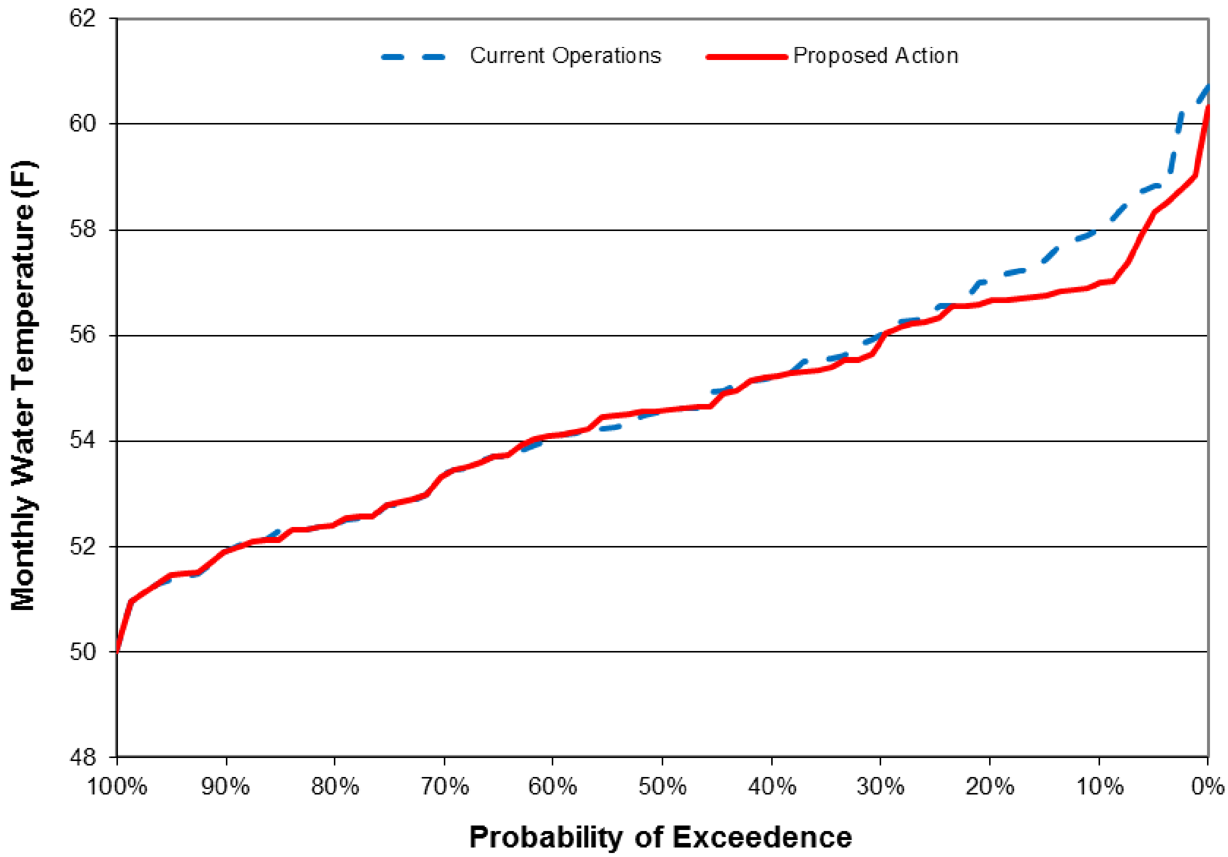


Figure 71. Exceedance plot of modeled water temperatures in the lower American River directly below Nimbus Dam during April.

Source: HEC-5Q Temperature Model results, 2019

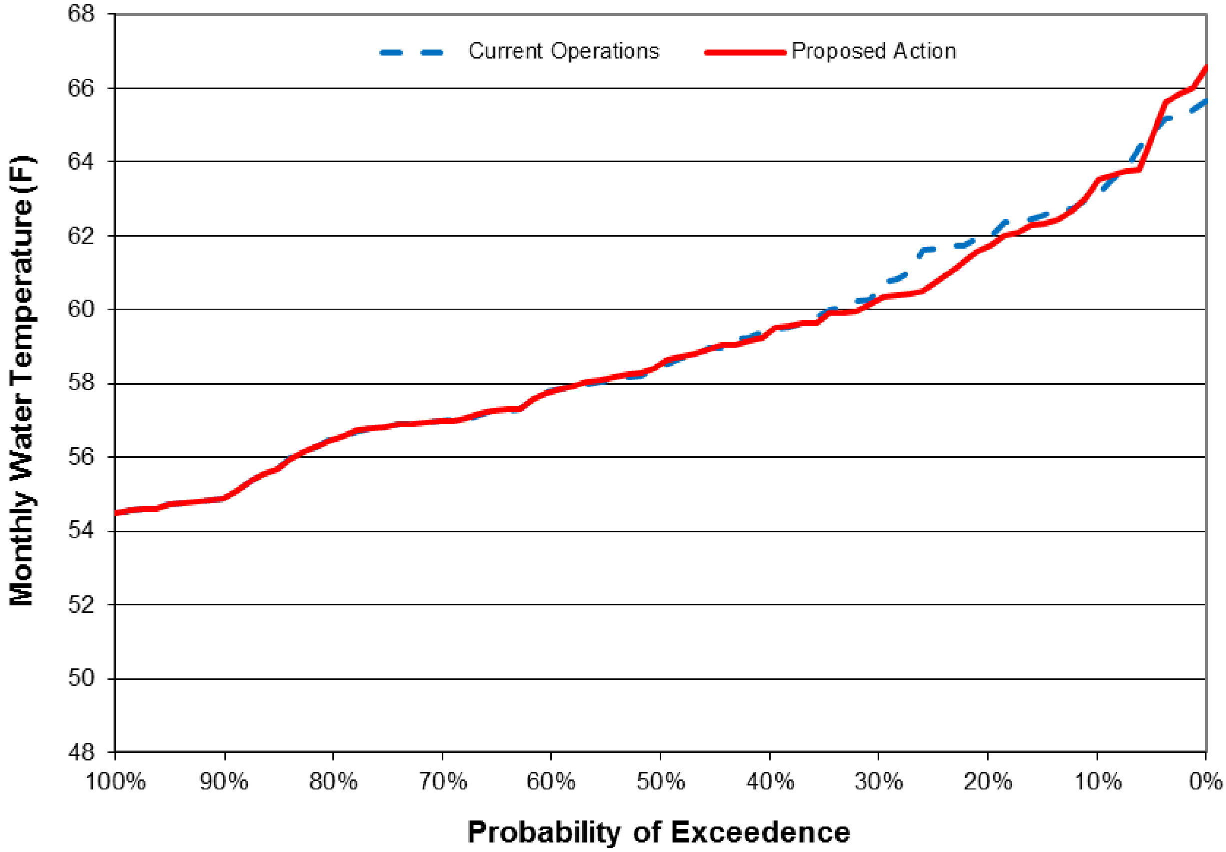
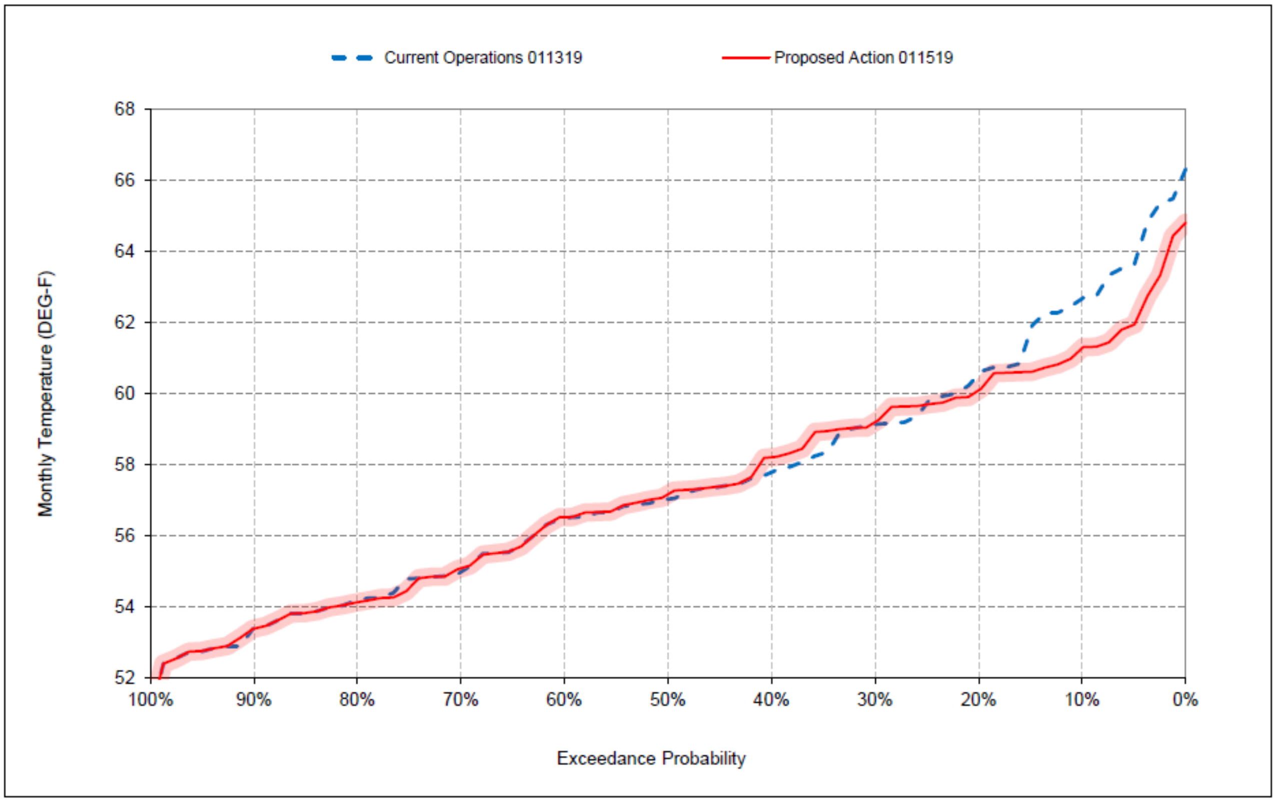


Figure 72. Exceedance plot of modeled water temperatures in the lower American River directly below Nimbus Dam during May.

Source: HEC-5Q Temperature Model results, 2019

Water temperatures at or above the 54°F to 57°F range during the steelhead egg incubation period are similar to current operations at Nimbus Dam, as shown in the April and May exceedance plots (Figure 73 and Figure 74). In April, modeled water temperatures exceeding 57°F occur about seven percent of the years in the proposed action and approximately 20 percent of the years in the current operating scenario (Figure 73). In May, modeled water temperatures exceeding exceeded 57°F 60 percent of the years in May (Figure 74) under the proposed action and the current operating scenario. The frequency of temperatures at Watt Ave above 60°F in April and 66°F in May are similar under the proposed action and the current operating scenario.

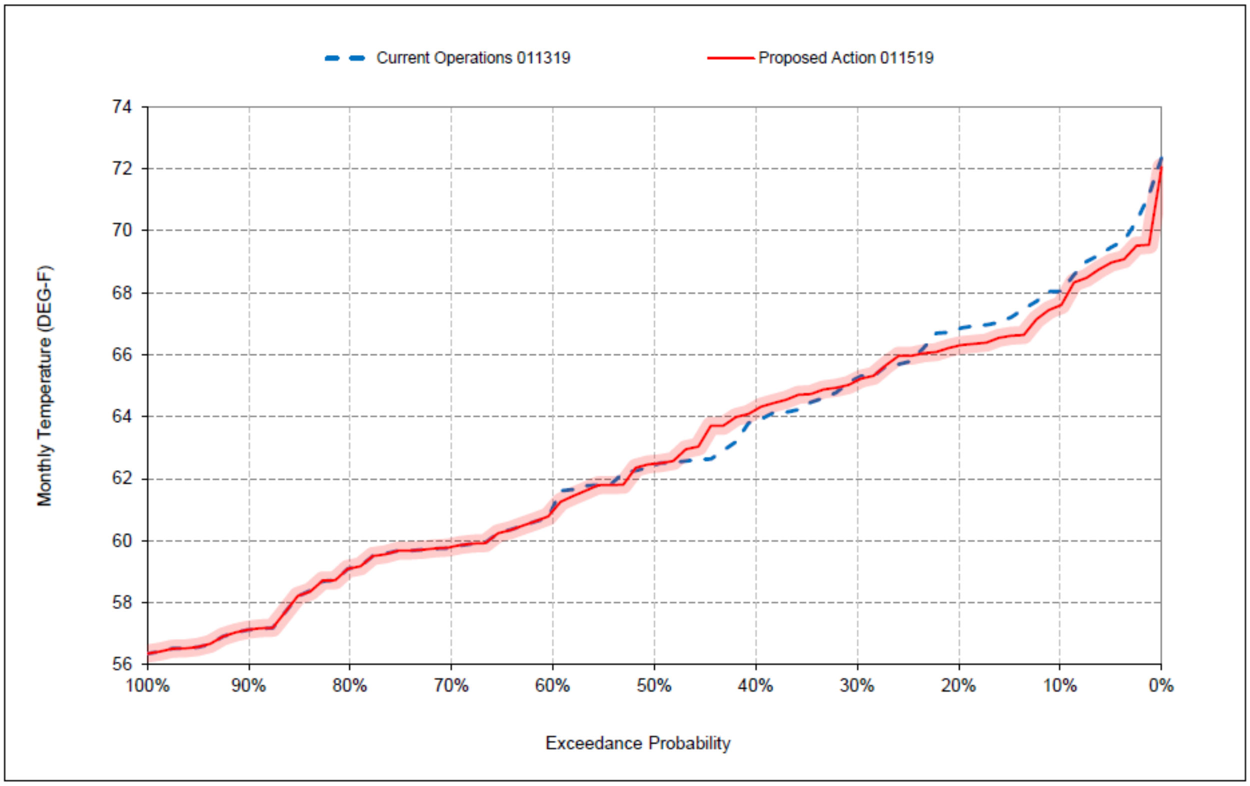


*All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.

*These are draft results meant for qualitative analysis and are subject to revision.

Figure 73. Exceedance plots of modeled water temperatures in the lower American River near Watt Avenue during April.

Source: HEC-5Q Temperature Model results, 2019



*All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.
*These are draft results meant for qualitative analysis and are subject to revision.

Figure 74. Exceedance plots of modeled water temperatures in the lower American River near Watt Avenue during May.

Source: HEC-5Q Temperature Model results, 2019

8.5.1.2 Juvenile Rearing

Water temperatures in the lower American River often reach and exceed levels that are stressful to juvenile rearing steelhead, particularly during the summer and early fall. Assessing the response of American River 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 recent increase in studies and modeling of growth and anadromy patterns using temperature as a variable (Beakes et al. 2014; Satterthwaite et al. 2010; Sogard et al. 2012), 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 steelhead may be more tolerant to high temperatures than steelhead from regions further north (Myrick and Cech 2004). Cech Jr and Myrick (1999) reported that when American River 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 steelhead from North Santiam River in Oregon occurred at a cooler temperature (i.e., 62.6°F). Furthermore, Beakes et al. (2014) found that steelhead sourced from Coleman National Fish Hatchery and reared at 68°F maintained an average growth rate above 0.6 mm/day, but only when a daily food ration equal to six 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 steelhead growth would likely be different. For example, the above Beakes et al. (2014) study found that treatments of high water temperature and low rations resulted in the lowest growth rate. Additionally, a field study conducted between 2006 and 2009 estimated that average summer and fall growth of juvenile steelhead in the American River ranged from 0.98 to 1.12 mm/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 CCV (e.g., Katz et al. 2017). Sogard et al. (2012) postulate that this rate of accelerated growth is likely the result of low 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, 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 steelhead has been reported by CDFW (formerly CDFG) to be associated with warm water temperatures (Figure 75). Sampling in the summer of 2004 showed that this vent inflammation was prevalent in 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 ten percent in August, to about 42 percent in September, and finally up to about 66 percent in October (Bratovich et al. 2005).

Figure 75. Anal vent inflammation in a juvenile steelhead from the American River.

Source: Bratovich et al. (2005)

The juvenile steelhead immune system properly functions up to about 60°F, and then is compromised as water temperatures increase into the upper 60°Fs (Bratovich et al. 2005). CDFW reports that, in 2004, the anal vent inflammation occurred when juvenile steelhead were exposed to water temperatures above 65°F (Bratovich et al. 2005). From 1999 through 2018, daily mean water temperatures during the summer at Watt Avenue were most often above 65°F, and during 2001, 2002, 2004, 2007, 2008, 2013, 2014, 2015, and 2016 water temperatures were often over 68°F (Figure 76). CDFW has suggested that these observations are associated with the debilitation of the steelhead's immune system responses (Bratovich et al. 2005). These observations may be indicative of an increased susceptibility to, and decreased ability to, deal with disease, which would decrease fitness.

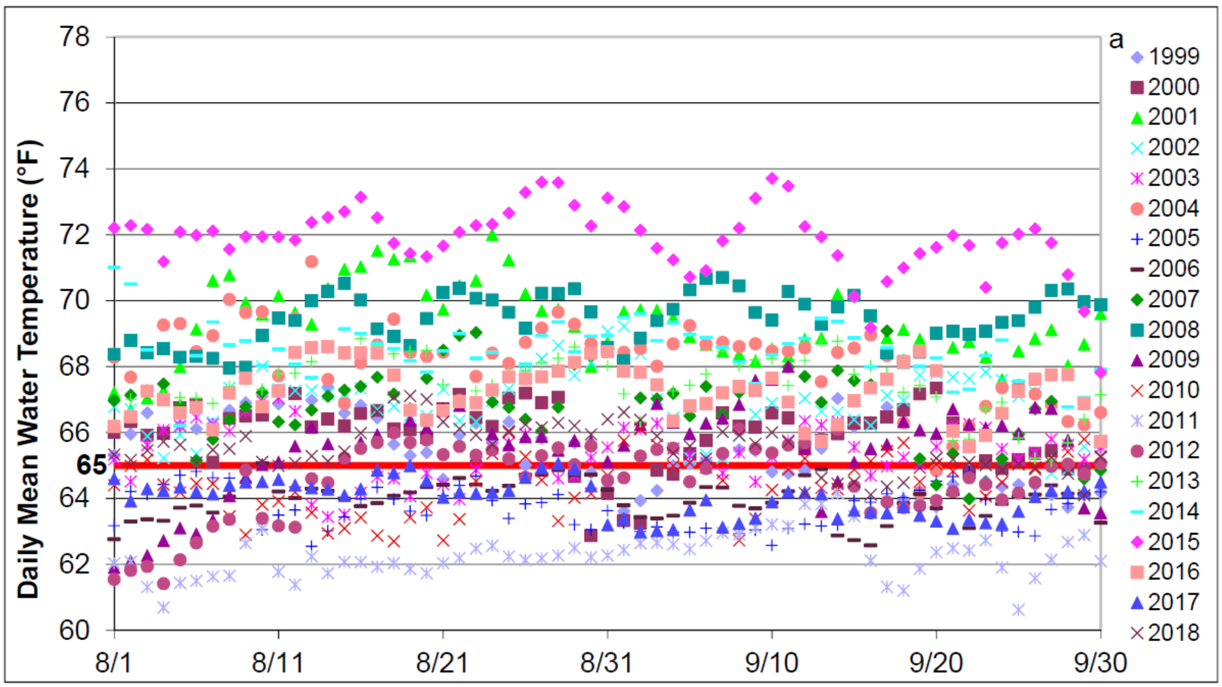


Figure 76. Lower American River water temperature during August and September from 1999 through 2018 represented as the daily mean at the Watt Avenue gauge.

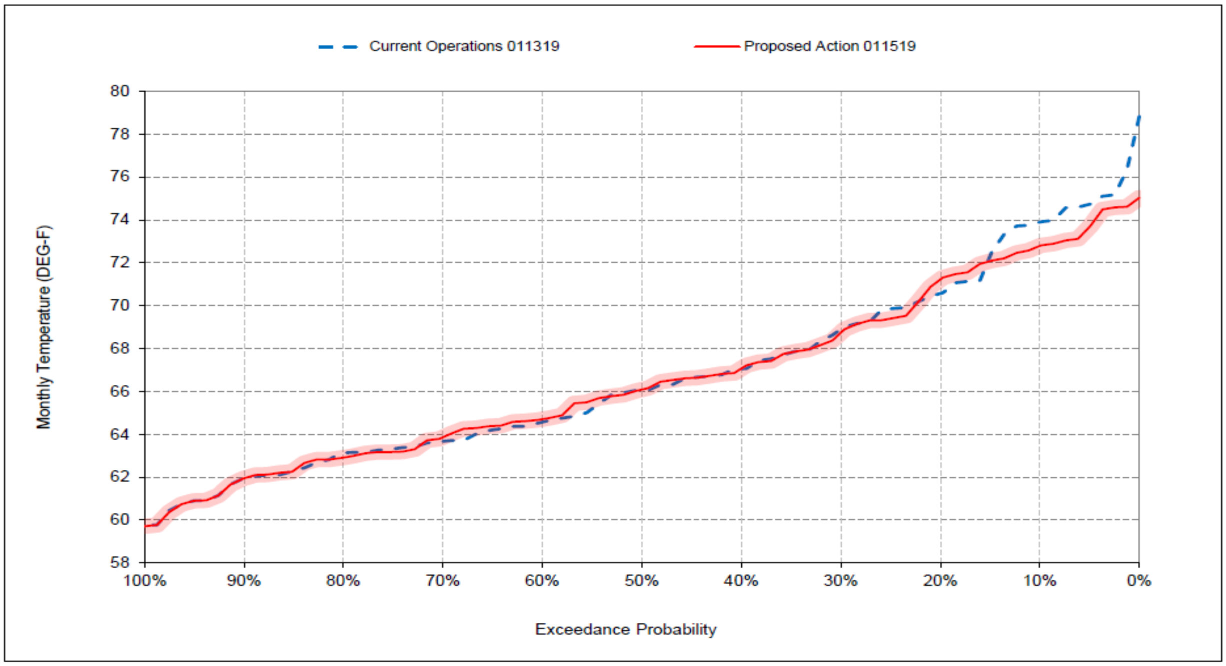
The 65°F line is indicated in red because visible symptoms of thermal stress in juvenile steelhead are associated with exposure to daily mean water temperatures above 65°F. Data were provided by Reclamation.

Based on water temperature modeling results presented in the ROC on LTO biological assessment, water temperatures associated with visible symptoms of thermal stress in juvenile steelhead (i.e., greater than 65°F) are expected to occur from June through September under both the proposed action and current operating scenario. Exceedance plots of monthly water temperatures at Watt Avenue show that temperatures are expected to be at or above 65°F for about 58 percent of the cumulative distribution in June (Figure 77), 100 percent in July (Figure 78), and about 95 percent of August (Figure 79) under both proposed action and current operating scenario. In September, model results show that 65°F will be exceeded 93 percent of the time under the current operating scenario and 96 percent of the time under the proposed action (Figure 80). Additionally, historic data between 1999 and 2018 show that on average only

43 percent of days from July through September are amenable to steelhead rearing using a temperature metric of 65°F; that number increases to 80 percent using a temperature metric of 68°F (Figure 81). When reviewing historic data, NMFS assumes potential climate change scenarios (+1°F and +3°F applied to historical water temperatures), would further reduce the temperature suitability of the lower American River for steelhead with less than 30 percent of days able to meet a 65°F temperature metric.

In the exceedance plots of monthly water temperatures (Figure 77 through Figure 80), the proposed action shows some improvements over current operating scenario at high temperatures, but the modeling results do not reflect the yet to be determined planning minimum carryover storage target intended to improve water temperatures. While the modeling includes a "soft" goal to maintain a minimum end-of-September storage of 275 thousand acre feet, this was partially intended to conceptually emulate the undefined end-of-December planning level minimum that (according to a meeting from Reclamation on May 31st) is expected to land between 200 and 300 thousand acre-feet. According to Reclamation in a meeting on May 31, 2019, Reclamation explained that the current planning level minimum is 200 thousand acre-feet and has been used historically for seasonal planning. Reclamation intends to share the final planning level minimum with NMFS along with the expected actions that the water users intend to take to improve storage conditions in years when the planning level minimum cannot be met solely by flexibility in CVP operations. Based on Reclamation's understanding of the expected performance from the planning level minimum, the CalSim modeling is the best representation of the proposed action. While the planning level minimum is not explicitly modeled, the increase from the existing planning level minimum is expected to improve storage conditions in certain years and help to protect the storage gains from the decreases in the minimum required releases in the proposed action as compared to the current operating scenario. The water temperature information presented here is primarily based on conditions in the vicinity of Watt Avenue (approximately river mile 9.4). Water temperatures become cooler with distance upstream to Nimbus Dam at river mile 23. As presented above, approximately 90 percent of steelhead spawning occurs upstream of the Watt Avenue Bridge (Hannon and Deason 2008) and juvenile rearing generally occurs in the vicinity of the upstream areas used for spawning. All juvenile steelhead must migrate through the lower sections of the American River, including the reach downstream of Watt Avenue, to reach the Sacramento River as smolts.

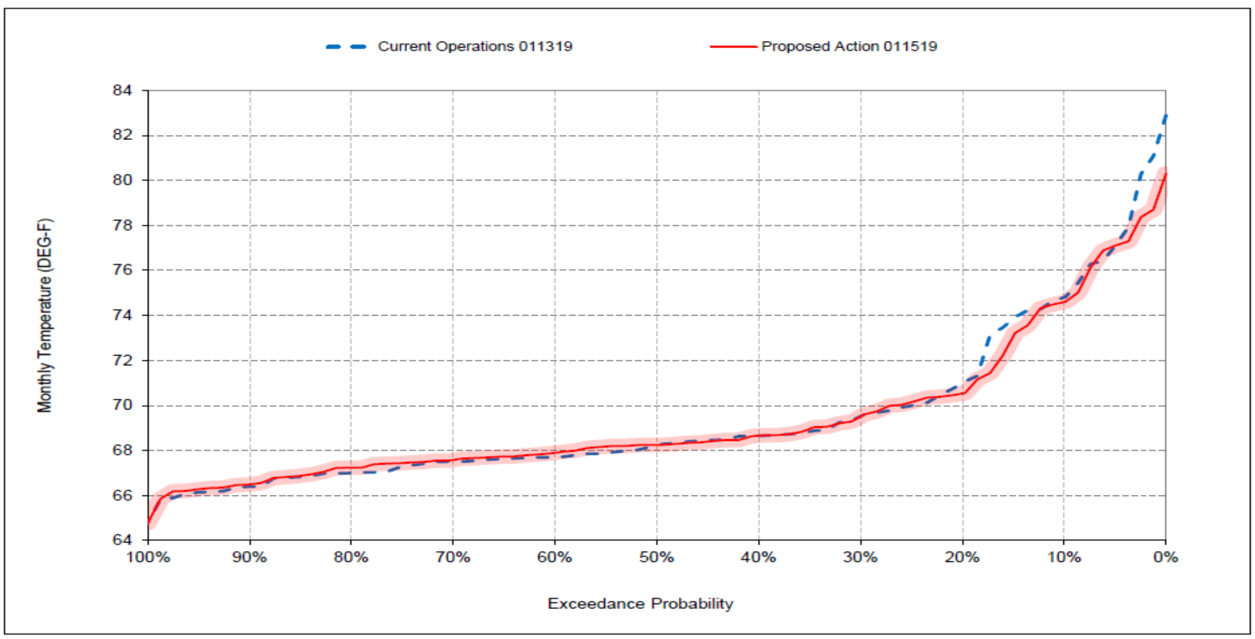
Despite efforts, lower American River water temperatures have not improved over at least the last 20 years. Although the proposed action, when compared to the current operating scenario, shows reductions in the frequency of the highest temperatures, the resulting temperatures are not assumed to solve the thermal challenges in the lower American River as the draft biological assessment does on pages 5-196 and 5-197 (U.S. Bureau of Reclamation 2019c): "*The implementation of the proposed 2017 FMS measures under the proposed action would provide suitable habitat conditions in the lower American River for CV Steelhead, particularly during drought conditions and improve conditions for this life stage*."



*All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.
*These are draft results meant for qualitative analysis and are subject to revision.

Figure 77. Exceedance plots of modeled water temperatures in the lower American River near Watt Avenue during June.

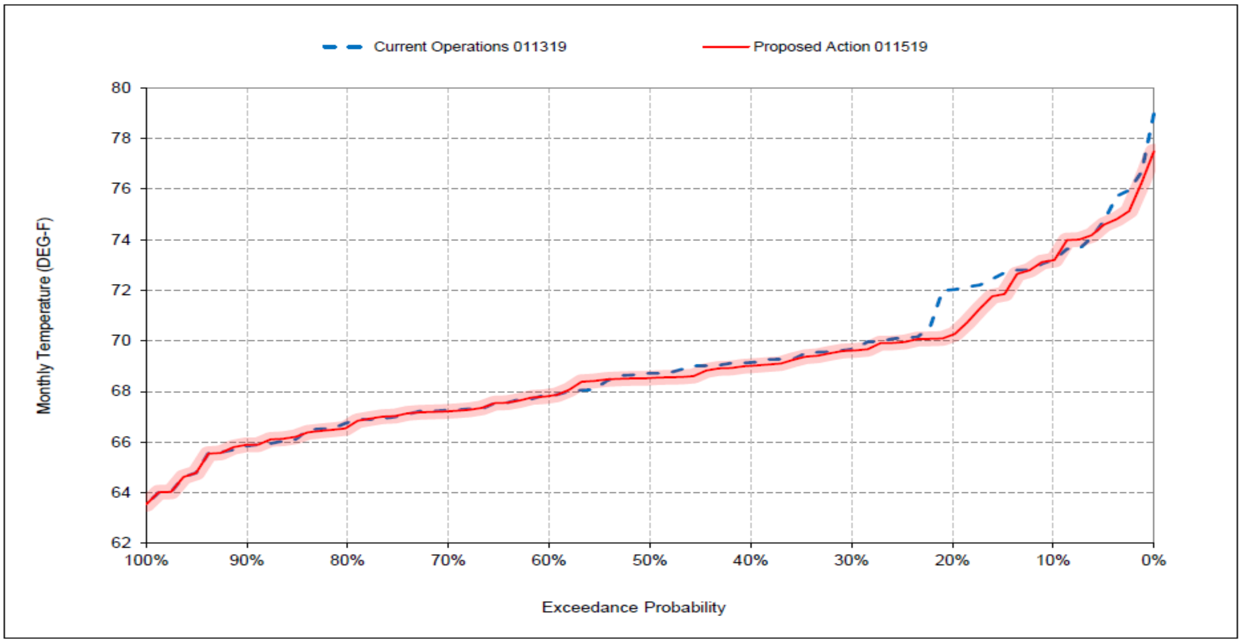
Source: HEC-5Q Temperature Model results, 2019



*All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.
*These are draft results meant for qualitative analysis and are subject to revision.

Figure 78. Exceedance plots of modeled water temperatures in the lower American River near Watt Avenue during July.

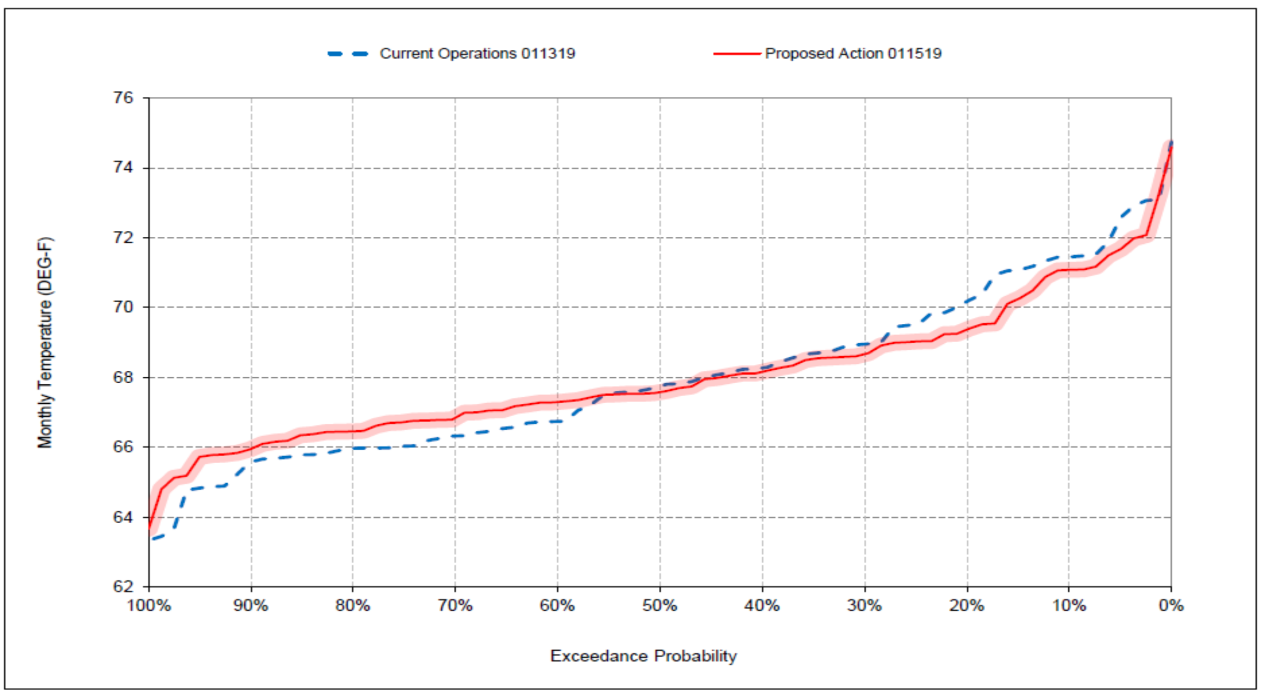
Source: HEC-5Q Temperature Model results, 2019



*All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.
*These are draft results meant for qualitative analysis and are subject to revision.

Figure 79. Exceedance plots of modeled water temperatures in the lower American River near Watt Avenue during August.

Source: HEC-5Q Temperature Model results, 2019



*All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.
*These are draft results meant for qualitative analysis and are subject to revision.

Figure 80. Exceedance plots of modeled water temperatures in the lower American River near Watt Avenue during September.

Source: HEC-5Q Temperature Model results, 2019

Table 45. Percent of days with temperatures in the lower American River amenable to steelhead rearing under historic and potential climate change conditions.

Percent Days with Lower American River Temperature Amenable to Steelhead Rearing

(65°F or 68°F) in Key July through September Period Under Historic (+0°F) or Climate Change (+1°F / 3°F) Scenarios

	68°F Metric			65°F Metric		
Year	+0°F	+1°F	+3°F	+0°F	+1°F	+3°F
1999	100%	97%	59%	59%	32%	9%
2000	100%	91%	32%	32%	21%	2%
2001	38%	20%	8%	8%	7%	5%
2002	93%	71%	32%	32%	17%	7%
2003	100%	100%	43%	43%	14%	0%
2004	50%	30%	5%	5%	1%	1%
2005	100%	100%	100%	100%	74%	0%
2006	100%	100%	100%	100%	67%	9%
2007	92%	65%	22%	22%	13%	0%
2008	18%	5%	0%	0%	0%	0%
2009	100%	97%	39%	39%	30%	13%
2010	100%	100%	85%	85%	55%	13%
2011	100%	100%	100%	100%	99%	61%
2012	100%	100%	71%	71%	36%	9%
2013	77%	49%	16%	16%	13%	0%
2014	33%	5%	0%	0%	0%	0%
2015	2%	0%	0%	0%	0%	0%
2016	88%	62%	15%	15%	12%	7%
2017	100%	100%	100%	100%	59%	5%
2018	100%	99%	32%	32%	7%	0%
Average	80%	70%	43%	43%	28%	7%

Source: CDEC webpage

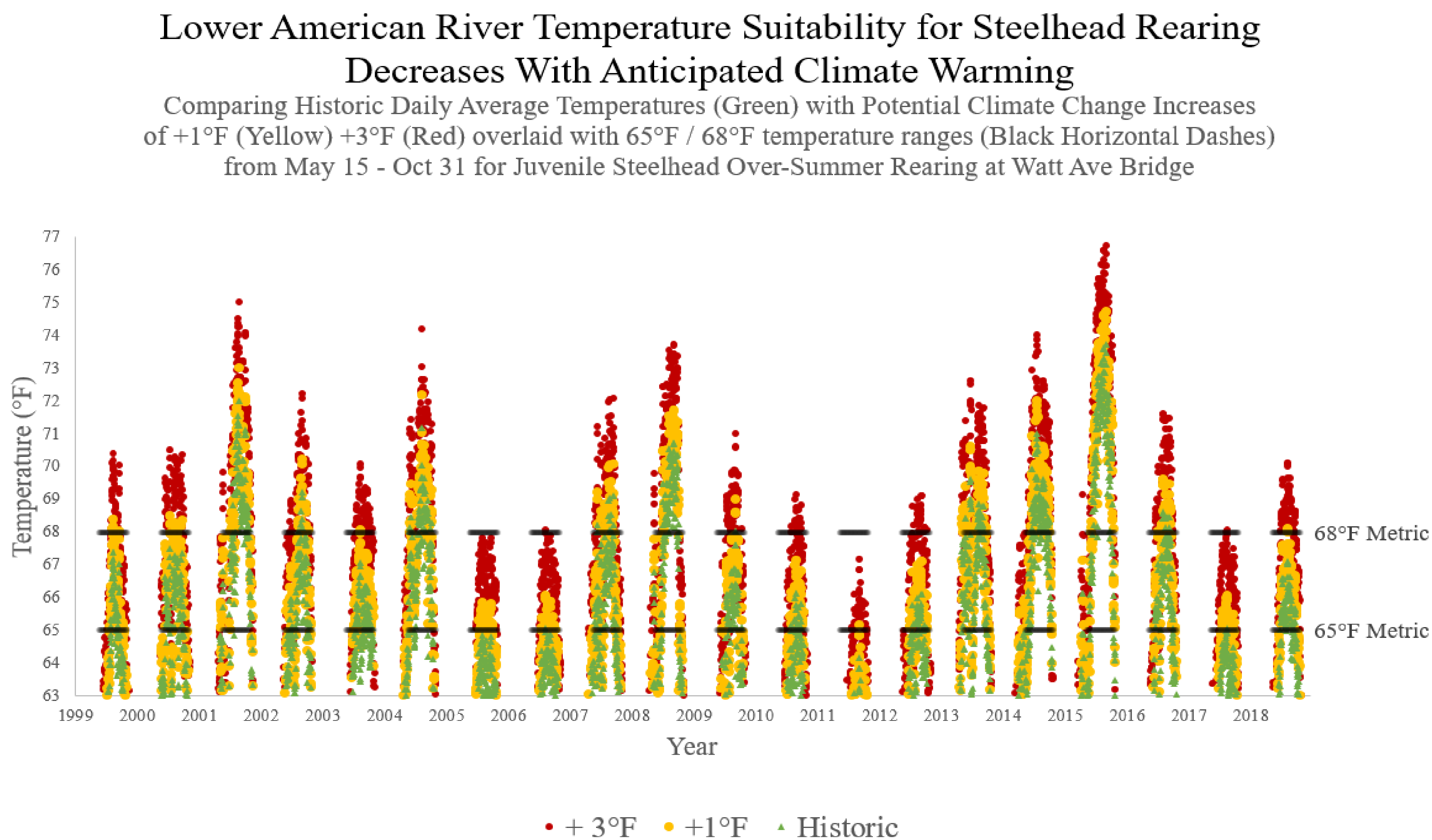


Figure 81. Lower American River temperature suitability for steelhead rearing under historic and potential climate change conditions.

Source: CDEC webpage

As described in (Water Forum 2005), Folsom Reservoir is commonly operated to meet water quality objectives and demands in the Delta. These operations limit coldwater 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 juvenile rearing steelhead. According to CDFW (2005) (as cited in Bratovich et al. 2005), water temperatures above 65°F are associated with a large (i.e., 30-40 species) complex warmwater fish community, including highly piscivorous fishes such as striped bass (*Morone saxatilis)*, largemouth bass (*Micropterus salmoides*), and Sacramento pikeminnow. Juvenile rearing steelhead may be exposed to increased 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).

Some striped bass reportedly reside in the lower American River year-round, although their abundance greatly increases in the spring and early summer as they migrate into the river at roughly the same time that steelhead are both emerging from spawning gravels as vulnerable fry and migrating out of the river as smolts (Surface Water Resources Inc. 2001). Striped bass are opportunistic feeders, and almost any fish or invertebrate occupying the same habitat eventually appears in their diet (Moyle 2002). Empirical data examining the effect of striped bass predation on steelhead in the lower American River have not been collected, although one such study was conducted in the Delta (California Department of Water Resources 2008). Results of this study concluded that steelhead of smolt size had a mortality rate within Clifton Court Forebay that ranged from 78 ± 4 percent to 82 ± 3 percent over the various replicates of the study. The primary source of mortality to these steelhead is believed to be predation by striped bass. Although Clifton Court Forebay and the lower American River are dramatically different systems, this study does demonstrate that striped bass are effective predators of steelhead. Considering that striped bass are abundant in the lower American River during the spring and early summer (Surface Water Resources Inc. 2001), when much of the steelhead initial rearing and smolt emigration life stages are occurring, striped bass predation on juvenile steelhead is considered to be an important stressor to this population. Although the predation stressor by striped bass is also considered in the baseline, the decrease in water temperatures and continued low flows that exist in both the current operating scenario and the proposed action are unlikely to reduce the magnitude of this stressor. As described below, low releases from Nimbus Dam force juvenile steelhead into areas that provide less cover from predation. The proposed action shows less frequent low flows. The model results show that, under the proposed action, American River flow below Nimbus is less than 500 cfs once in July, twice in August, and twice in September in the 82 year (984 month) simulation period. Under the current operating scenario, however, this occurs more frequently: one occurrence in October, three occurrences in (each of the following months) January, February, April, May, June, August, and four occurrences in (each of the following months) March, July, and September.

Overall, the proposed action includes some improvement (reduction) in water temperature but direct sublethal impacts and indirect lethal impacts (predation) for a high proportion of the American River steelhead population in nearly all years is still expected, supporting a medium to high magnitude classification for this stressor.

8.5.1.3 Smolt Emigration

To successfully complete the parr-smolt transformation, a physiological and morphological adaptation to life in saline water, smolting steelhead require cooler water temperatures than for the rearing life stage. Adams et al. (1975) reported that 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 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 steelhead smoltification (U.S. Environmental Protection Agency 2001; Wedemeyer et al. 1980; Zaugg et al. 1972).

Steelhead smolt emigration in the lower American River occurs from January through June (Surface Water Resources Inc. 2001). Monitoring data from 1999 through 2018 showed that lower American River water temperatures frequently exceeded 52°F by March and exceeded 54°F in all but 5 years by April (Figure 70). Based on the thermal requirements for steelhead smolts described above, it could be hypothesized that smolt transformation is likely inhibited by exposure to lower American River water temperatures. However, recent research has shown that most 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 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 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 similar conditions to the current operating scenario that will inhibit the successful transformation from parr to smolts. For example, exceedance plots show that water temperatures at Watt Avenue will be warmer than 54°F for 83 percent of the years in April (Figure 73) under both the current operating scenario and the proposed action scenarios. In May water temperatures are expected to exceed 58°F in 85 percent of the years (Figure 74) and in June modeling results suggest that they will always be over 58°F under both the current operating scenario and the proposed action (Figure 77). These data suggest that smolts are expected to experience sublethal thermal impacts under both the current operating scenario and the proposed action for at least the small proportion of steelhead emigrating in April, May, and June.

8.5.1.4 Minimum Flow Schedule and Water Temperature Standards

Reclamation proposes to adopt the minimum flow schedule and approach proposed by the Water Forum in 2017[10] and highlights a new planning minimum process. The ROC on LTO proposed action (U.S. Bureau of Reclamation 2019c) states that:

[10] The biological assessment refers a 2017 proposal, however the subject document provided to NMFS by Reclamation is dated December 2018 and has the title of: Lower American River – Standards for Minimum Flows.

> "*Reclamation proposes to work together with the American River water agencies to define an appropriate amount of storage in Folsom Reservoir that represents the lower bound for typical forecasting processes at the end of calendar year (the "planning minimum"). The planning minimum brings Reclamation's forecasting process together with potential local actions that either increase Folsom storage or reduce demand out of Folsom Reservoir. The implementation of a planning minimum allows Reclamation to work with the American River Group to identify conditions when local water actions may be necessary to ensure storage is adequate for diversion from the municipal water intake at Folsom Dam and/or the extreme hydrology presents a risk that needs to be properly communicated to the public and surrounding communities. This planning minimum will be a single value (or potentially a series of values for different hydrologic year types) to be used for each year's forecasting process into the future. The objective of incorporating the planning minimum into the forecasting process is to provide releases of salmonid-suitable temperatures to the lower American River and reliable deliveries (using the existing water supply intakes and conveyance systems) to American River water agencies that are dependent on deliveries or releases from Folsom Reservoir. This planning minimum is expected to be initially defined in 2019; however, it will be continuously evaluated between Reclamation and the Water Forum throughout implementation*."

Based on the modeling information provided in the ROC on LTO biological assessment, the temperature standard of 65°F described in the ROC on LTO proposed action cannot always be met. According to the proposed action, the temperature management planning process will aim to attain the best possible temperature schedule for the compliance point at Watt Avenue Bridge. In conditions when the target temperature can not be met, higher temperatures will be targeted to most efficiently use the available coldwater pool. Reclamation states that the draft temperature management plan will be shared with the American River Group before finalization, where NMFS assumes Reclamation will receive input on potential higher temperatures due to limited coldwater pool availability. The proposed action states the following:

- "*Reclamation proposes to manage the Folsom/Nimbus Dam complex and the water temperature control shutters at Folsom Dam to maintain 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 Steelhead rearing in the lower American River."*

- *"During the May 15 to October 31 period, if the Temperature Plan defined 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. The priority for use of the lowest water temperature control shutters at Folsom Dam shall be to achieve the water temperature requirement for listed species (i.e., Steelhead), and thereafter may also be used to provide cold water for Fall-Run Chinook Salmon spawning."*

Modeling of both the proposed action and the current operating scenario provided in the ROC on LTO proposed action indicate 65°F will be regularly exceeded. NMFS assumes that this exceedance will occur under the implementation of the proposed action due to similar constraints under the current operating scenario. These include:

(1) operational (e.g., Folsom Reservoir operations to meet Delta water quality objectives and demands and deliveries to municipal and industrial users in Sacramento County) and structural (e.g., limited reservoir water storage and coldwater pool) factors limit the availability of coldwater for water temperature management;

(2) despite careful planning and the annual development of a water temperature management plan, in most years since the late 1990s, Reclamation has not achieved the temperatures (NMFS 2009 Opinion and analysis of recent temperatures presented in this Opinion);

(3) climate change impacts are expected to continue, which will likely further constrain lower American River water temperature management.

A comparison of north-of-Delta deliveries to CVP municipal and industrial contractors, which are mostly in the American River Basin, using CalSim II modeling, shows that the current operating scenario and proposed action values are relatively similar in most year-types, with slightly higher deliveries being made in below normal water year types under the proposed action compared to the current operating scenario. This slight increase is supported by Table 5-3 in the ROC on LTO biological assessment (Appendix D, Attachment 3-1), which shows decreases in Folsom Lake storage in below normal water year types under the proposed action compared to the current operating scenario.

8.5.1.5 Conservation Measure - Water Temperature Management During Drought

Reclamation proposes the following conservation measure in the ROC on LTO proposed action (U.S. Bureau of Reclamation 2019c): that involves temperature management in the American River:

"*Drought Temperature Management: In severe or worse droughts, Reclamation proposes to evaluate and implement alternative shutter configurations at Folsom Dam to allow temperature flexibility*."

The level of detail provided in ROC on LTO proposed action on this measure is not sufficient to quantify the level of potential effect on CCV steelhead. Based on conversations with Reclamation in May 2019, NMFS understands that this action refers to a practice known as "deganging" the current temperature shutters to allow a more efficient use of the available coldwater pool. Deganging may be more efficient owing to the increased ability to fine tune release temperatures via the increased number of potential shutter configurations. The benefits of this action for future drought years has not been modeled but is expected to allow for longer use of the warmer water in the reservoir and reserve cooler water for later in the temperature management season. Historically, this operation has only occurred once, in 2015. We assume the conservation measure may continue to minimize temperature-related impacts to CCV steelhead in a more efficient manner than annual temperature shutter operations.

8.5.1.6 Magnitude of Water Temperature as a Stressor to American River Steelhead

This effects analysis indicates that the thermal impacts on lower American River steelhead expected to occur with implementation of the proposed action will be similar to the impacts associated with the recent past operations of the American River Division of the CVP. Water temperature under the proposed action is considered a medium to high magnitude stressor based on the exposure of multiple steelhead life stages to lethal and sublethal conditions in all but the wettest and coldest years, and without structural modifications to Folsom Dam, this stressor would continue.

8.5.2 Lower American River Flow Management

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 of time followed by rapid flow decreases. Releases from Folsom Dam are re-regulated approximately seven miles downstream by Nimbus Dam. A few examples of these types of flow fluctuations can be seen in the Nimbus Dam release pattern, which occurred in 2004 (Figure 82). Reclamation operates for flood control in accordance with the 2019 Water Control Manual. The proposed action does not propose changes to flood control operations from the current water control manual and therefore, these impacts from passing high flow events would be consistent between the current operating scenario and the proposed action.

Reclamation and the U.S. Army Corps of Engineers 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 Outlet Tubes. 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 thru 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 Corps as the federal action agency (National Marine Fisheries Service 2018d), and analyses and terms and conditions in that Opinion are in the baseline for this consultation. The operation under the new Water Control Manual with the new spillway is expected to result in decreases of peak flows with potential longer durations of flood releases to evacuate the same volume when compared to historical operations. For this reason, using historical data for flood control is not appropriate.

8.5.2.1 Flow Fluctuations

Flow fluctuations in the lower American River have been documented to result in steelhead redd dewatering and isolation (American River Group 2017; American River Group 2018; Hannon and Deason 2008; Hannon et al. 2003; Water Forum 2005). 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 (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 steelhead redds were dewatered and ten 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 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 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 steelhead redd, and several more redds were of unknown origin (Hannon and Deason 2008) (Figure 83). Surveys performed in the lower American River by Cramer Fish Sciences in 2018 (American River Group 2018) documented dewatering of steelhead redds in March 2018.

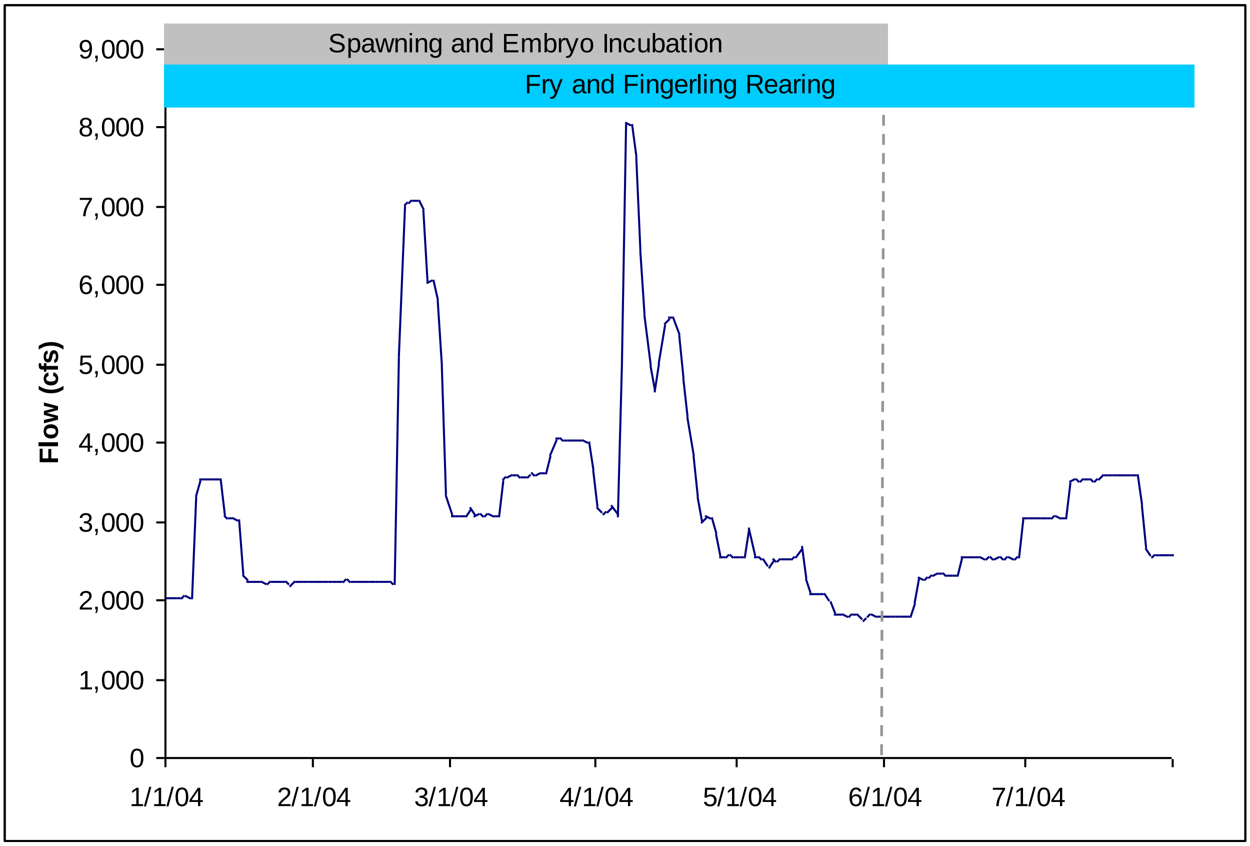


Figure 82. Mean daily release rates from Nimbus Dam in January through July of 2004.

Although reports of steelhead redd dewatering and isolation in the lower American River are limited to 2003, 2004, 2006 (Figure 83), and 2018, these effects have likely occurred in other years because: (1) the pattern of high releases followed by lower releases which occurred during the steelhead spawning period (i.e., primarily January through March) in 2003, 2004, 2006, and 2018 is similar to the pattern observed during the spawning period in many other years (CDEC data (http://cdec.water/ca/gov/) from 1994 through 2019); and (2) monitoring was not conducted during many release events and, consequently, impacts were not documented. Impacts associated with flow fluctuations are expected to continue to occur with implementation of the proposed action through 2030.

Juvenile steelhead isolation has also been reported to occur in the lower American River. For example, Bratovich et al. (2005) reported that juvenile 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. Surveys conducted by Cramer Fish Sciences in 2017 and 2018 documented stranding of juvenile steelhead and Chinook salmon in isolated pools of the lower American River (American River Group 2017; American River Group 2018). 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 steelhead in that habitat are assumed to die.

Flow fluctuations in the American River under the proposed action are expected to impact a small proportion of steelhead eggs and juveniles with a medium annual frequency, supporting a medium stressor magnitude classification for both life stages.

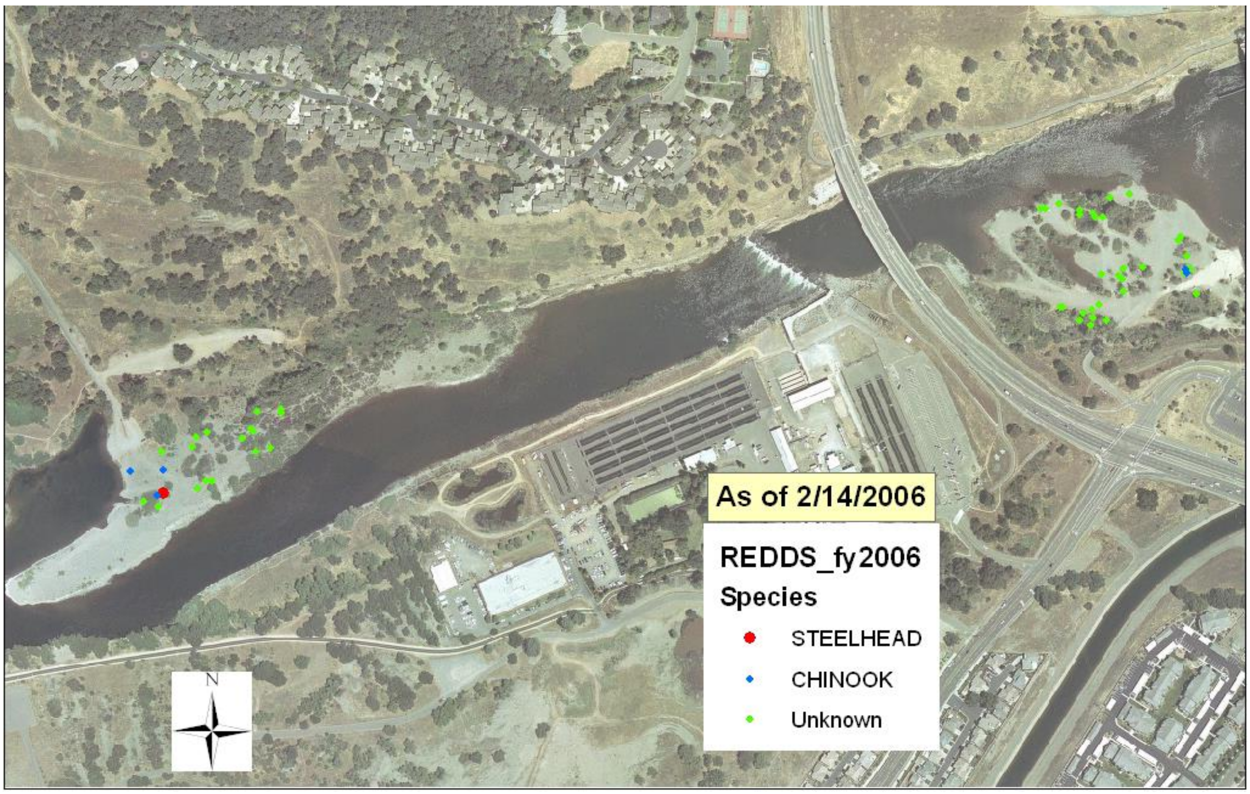


Figure 83. Dewatered redds at Nimbus Basin and Sailor Bar, February 2006.

Source: modified from (Hannon and Deason 2008)

8.5.2.2 Low Flows

In addition to flow fluctuations, low flows also can negatively affect lower American River steelhead. Yearling 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 steelhead densities to increase in areas that provide less cover from predation. With high densities in areas of relatively reduced habitat quality, juvenile steelhead become more susceptible to predation as well as disease. Low flows are included in both the proposed action and the current operating scenario; however, the proposed action shows less frequent low flows. The model results show that, under the proposed action, American River flow below Nimbus is less than 500 cfs once in July, twice in August, and twice in September in the whole 82 year (984 month) simulation period. Under the current operating scenario, however, this occurs more frequently: one occurrence in October, 3 occurrences in (each of the following months) January, February, April, May, June, August, and 4 occurrences in (each of the following months) March, July, and September. Periodic exposure of a small proportion of American River juvenile steelhead to these low flow conditions is expected during implementation of the proposed action through 2030, although less frequently than under the current operating scenario.

8.5.2.3 2017 Flow Management Standard Releases and "Planning Minimum"

See Section 8.5.1.4 Minimum Flow Schedule and Water Temperature Standards.

8.5.2.4 Spawning Habitat Availability

Modeling results show that flows under the proposed action provide slightly lower steelhead spawning habitat for about 10 percent of years, relative to current operations, but otherwise the proposed action matches the current operating scenario (Figure 84).

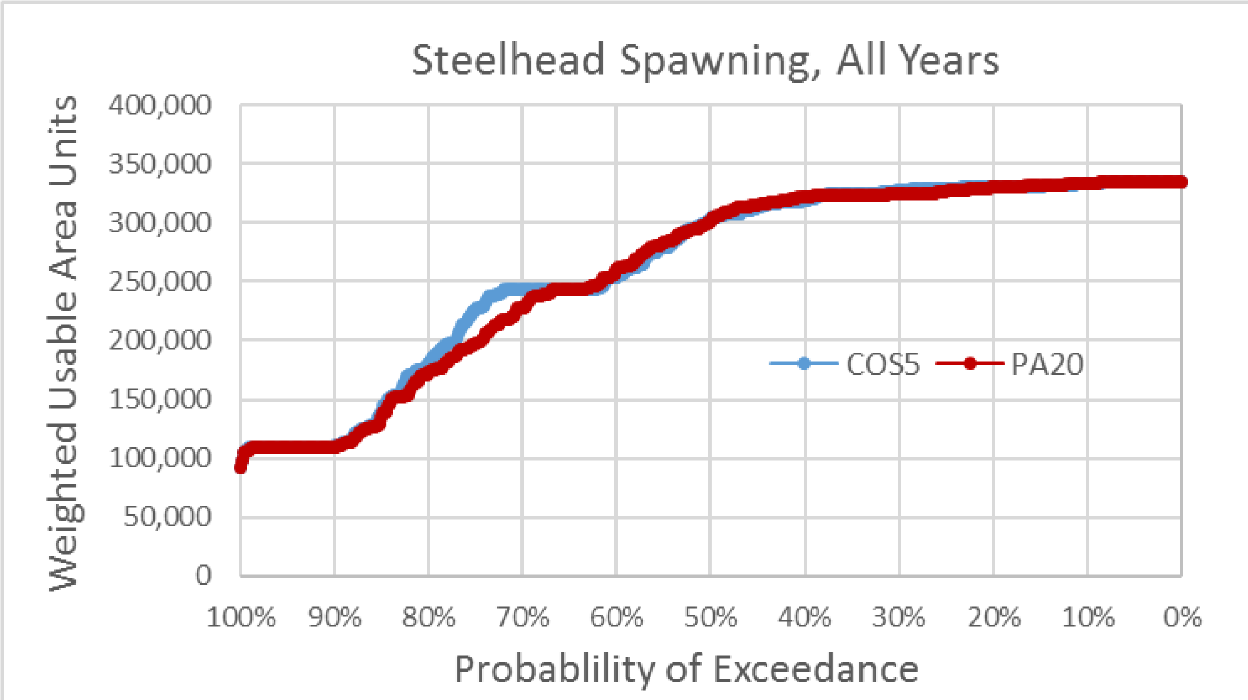


Figure 84. Steelhead spawning habitat availability under the proposed action (PA20) and under current operations (current operating scenario5) over all water year types.

Source : provided by Reclamation

8.5.2.5 Magnitude of Flow Management as a Stressor to American River Steelhead

This effects analysis indicates that the flow-related impacts on lower American River steelhead expected to occur with implementation of the proposed action will be similar to the impacts associated with the recent past CVP operations. Flow management under the proposed action is considered a medium magnitude stressor based on the expected periodic occurrence of lethal and sublethal impacts resulting from redd dewatering, fry stranding, and juvenile isolation.

8.5.3 Conservation Measures

Reclamation included two conservation measures as part of its proposed action to support CCV steelhead in the American River. These measures are assessed in this section.

8.5.3.1 Spawning and Rearing Habitat Restoration

In ROC on LTO biological assessment, Reclamation states "conservation measures include non-flow actions that benefit listed species without impacting water supply or other beneficial uses."

"Spawning and Rearing Habitat Restoration: Project activities include primarily side channel and floodplain creation, expansion, and grading, spawning gravel and large cobble additions, and woody material additions. Pursuant to CVPIA 3406(b)(13), Reclamation proposes to implement the following projects: Paradise Beach, Howe Avenue to Watt Avenue rearing habitat, William Pond Outlet, Upper River Bend, Ancil Hoffman, El Manto, Sacramento Bar North, Sacramento Bar South, Lower Sunrise, Sunrise, Upper Sunrise, Lower Sailor Bar, Upper

Sailor Bar, Nimbus main channel and side channel, Discovery Park, Cordova Creek Phase II, Carmichael Creek Restoration and Sunrise Stranding Reduction. Reclamation proposes to continue maintenance activities at Nimbus Basin, Upper Sailor Bar, Lower Sailor Bar, Upper Sunrise, Lower Sunrise and River Bend restoration sites."

Several restoration projects have undergone section 7 consultation and have been completed on the American River that require maintenance to retain their benefit, such as gravel augmentation. The effects of these conservation actions are part of the environmental baseline because they previously have undergone ESA section 7 consultation either through individual or programmatic actions. Similarly, any past restoration activities that were completed under the NMFS 2009 Opinion are also considered part of the environmental baseline. Those restoration actions have been consulted on previously such that their past and future beneficial effects to increased spawning and rearing habitat for listed salmonids are factored into the environmental baseline. Because river flows, particularly high river flows, move and re-distribute gravel downstream, additional gravel placement may be necessary to maintain the habitat improvement. Reclamation proposes to continue supporting the gravel restoration program into the future. Additional section 7 consultation may be required for some of these projects. At the framework-level, we expect continued benefits to CCV steelhead, including increased production and growth and survival from this habitat restoration action.

8.5.3.2 Nimbus Fish Hatchery Hatchery and Genetics Management Plans

Reclamation intends to improve the status of CCV steelhead and fall-run CV Chinook salmon in the American River by developing HGMPs for these species. The steelhead HGMP will describe hatchery operations and associated monitoring to reduce genetic introgression from the out-of-basin Nimbus Hatchery broodstock, implement practices to reduce straying and eliminate inter-basin transfers from Nimbus hatchery, and promote a CCV steelhead DPS population in the American River. The fall-run Chinook Salmon HGMP will describe hatchery operations and associated monitoring to reduce impacts on hatchery Chinook salmon on natural fall-run CV Chinook salmon and minimize effects on the genetic diversity and run-timing of American River fall-run CV Chinook salmon. Within six months of completion of the consultation, Reclamation will work with CDFW and NMFS to establish a clear understanding on this conservation measure's goals, appropriate time horizons, and reasonable cost estimates for this effort.

In order to provide enough certainty regarding how and when the proposed action component would be implemented, and to assess its effects, the HGMP will need to be developed further. Generally, an HGMP would be expected to have beneficial effects by improving the genetic management of steelhead within the Nimbus Fish Hatchery and decreasing the potential negative effects of environmental conditions and water operations. These general beneficial effects are included in this analysis of effects in this Opinion at the framework level.

8.5.4 Division Effects Summary

The following tables summarize the project-related stressors on CCV steelhead by lifestage and proposed action component. The 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.

The effects analysis results suggest that water temperature will be a medium to high magnitude stressor on American River steelhead, flow management will be a medium stressor on American River steelhead, and operation of the Nimbus Fish Hatchery Steelhead Program will be a medium or high magnitude stressor on the population (and DPS), depending on the hatchery production release location. Based on the responses of steelhead exposed to the proposed action described above, fitness consequences to individuals include reduced survival during egg incubation, reduced survival and growth during juvenile rearing, reduced survival during smolt emigration, and reduced genetic integrity (Table 46, Table 47, and Table 48).

Table 46. Summary of proposed action for American River Division operation-related effects on egg and fry California Central Valley steelhead.

Action Component	Stressor	Individual Response and Rationale of Effect	Severity of Stressor/Level of Benefit	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness
Water Temperature Management	Water temperatures warmer than life stage requirements, upstream of Watt Ave. in April and May	reduced early life stage viability; direct mortality	sublethal and lethal	small	high	medium	high	Continued reduced survival, slightly improved over current conditions
Water Flow Managment	Folsom/Nimbus releases	redd dewatering and isolation	lethal	small	medium	medium	high	Continued reduced survival

Table 47. Summary of proposed action for American River Division operation-related effects on juvenile California Central Valley steelhead.

Action Component	Stressor	Individual Response and Rationale of Effect	Severity of Stressor/Level of Benefit	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness
Water Temperature Management	water temperatures warmer than life stage requirements, downstream of Watt Ave. during March through June	reduced ability to successfully complete the smoltification process, increased susceptibility to predation	sublethal	small	medium	medium	High	Continued reduced growth and survival

Action Component	Stressor	Individual Response and Rationale of Effect	Severity of Stressor/Level of Benefit	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness
Water Temperature Managment	Water temperatures warmer than life stage requirements, upstream of Watt Ave. during June through September	susceptibility to disease at temperatures above	sublethal	high	high	high	medium	reduced growth and survival, slightly improved over current operations
Water Flow Managment	Folsom/Nimbus releases – flow fluctuations; low flows, during late summer and early fall	fry stranding and juvenile isolation; low flows limiting the availability of quality rearing habitat including predator refuge habitat	lethal	small	medium	medium	Low	reduced survival

Table 48. Summary of proposed action for American River Division operation-related effects on adult California Central Valley steelhead.

Action Component	Stressor	Individual Response and Rationale of Effect	Severity of Stressor/Level of Benefit	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness
Water Flow Managment	Folsom/Nimbus releases – flow fluctuations	redd dewatering and isolation	lethal	small	medium	high	High	reduced survival, reduced reproductive success

Action Component	Stressor	Individual Response and Rationale of Effect	Severity of Stressor/Level of Benefit	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness
American River	Nimbus Hatchery – hatchery *O. mykiss* spawning with natural-origin steelhead	Improved genetic diversity from development of HGMP	sublethal	small	high	high	High	Gradual improvement of existing reduced genetic integrity
Habitat Restoration	Limited spawning and rearing habitat	Improved spawning habitat, increased rearing habitat	Beneficial: sublethal	Medium	High	Medium	Medium	Increase in productivity, growth rates and survival of juveniles

8.6 Bay-Delta Division

During consultation, discussions between NMFS and Reclamation resulted in revisions to the proposed action that were not captured in the February 5, 2019, biological assessment. Unless otherwise noted, Sections below are based on the modeling associated with the February 5, 2019 proposed action (U.S. Bureau of Reclamation 2019c, the original proposed action) and associated modeling that NMFS requested. Supplemental effects analysis to assess the effects of the June 14, 2019 proposed action revisions reflected in the final proposed action (U.S. Bureau of Reclamation 2019b), including a discussion of whether and how the proposed action revisions modify the effects analyzed, are included within the subsections for proposed action components, as appropriate.

NMFS deconstructed the proposed action to identify the project components that would create stressors that may affect listed species (Table 49). The exposure, risk, and response of each species to the project-related stressors are then analyzed in the following sections for each proposed action component.

Table 49. Stressors created by the components of the proposed action in the Bay-Delta Division.

Project Component	Passage Impediments/ Barriers	Water Temperature	Water Flow	Entrainment
Delta Cross Channel	X		X	X
North Bay Aqueduct			X	X
Contra Costa Water District – Rock Slough Diversion			X	X
Water Transfers			X	X
Suisun Marsh	X			X
South Delta Export Operations			X	X
South Delta Salvage and Entrainment			X	X
Integrated Early Water Pulse Protection Turbidity Event			X	X
Salmonid Onset Trigger			X	X
End of Old and Middle River Management			X	X
Additional Real-time Old and Middle River Management			X	X
Storm Related Old and Middle River Flexibility			X	X
Minimum Export Rate			X	X
Predator Removal (CO_2 Injection)			XWQ	
Tracy Fish Collection Facility Release Sites Improvements				
Predator Removal from Clifton Court Forebay - PRES				
Predator Removal from Clifton Court Forebay - PFRS				
Aquatic Weed Control for Predator Habitat				
Operational Changes when Listed Fish are Present			X	X
Clifton Court Forebay Aquatic Weed and Algal Bloom Control			XWQ	
South Delta Agricultural Barriers	X		X	
Conservation Actions				
Fall Delta Smelt Habitat				
San Joaquin Basin Steelhead Telemetry Study				
Sacramento Deep Water Ship Channel Food Study	X	X	X	X
North Delta Food Subsidies/ Colusa Basin Drain and Suisun Marsh Roaring River Distribution System Food Subsidy Studies			XWQ	
Tidal Habitat Restoration of 8,000 acres			XWQ	X
Predator Hot Spots	X			
Delta Fish Species Conservation Hatchery				

An "X" indicates that the action component affects a stressor category; the response could be negative or positive.
"XWQ" indicates the stressor is influenced by the project component and relates to water quality.

8.6.1 Delta Conceptual Model and Recent Delta Science

Many proposed action components in the Delta affect several life stages of salmonids and green sturgeon rearing, sheltering, and migrating (Figure 85). The many interacting factors make it hard to isolate or quantify the effect of any one Delta Division component, especially on "large-scale" effects metrics such as through-Delta survival. The correlations among environmental variables add to the challenge.

NMFS considers several types of water project-related effects on salmonids in the south Delta as captured in the conceptual model of the 2017 (Salmonid Scoping Team 2017a; Salmonid Scoping Team 2017b) report which links hydrodynamics to migration behavior and survival (Figure 86).

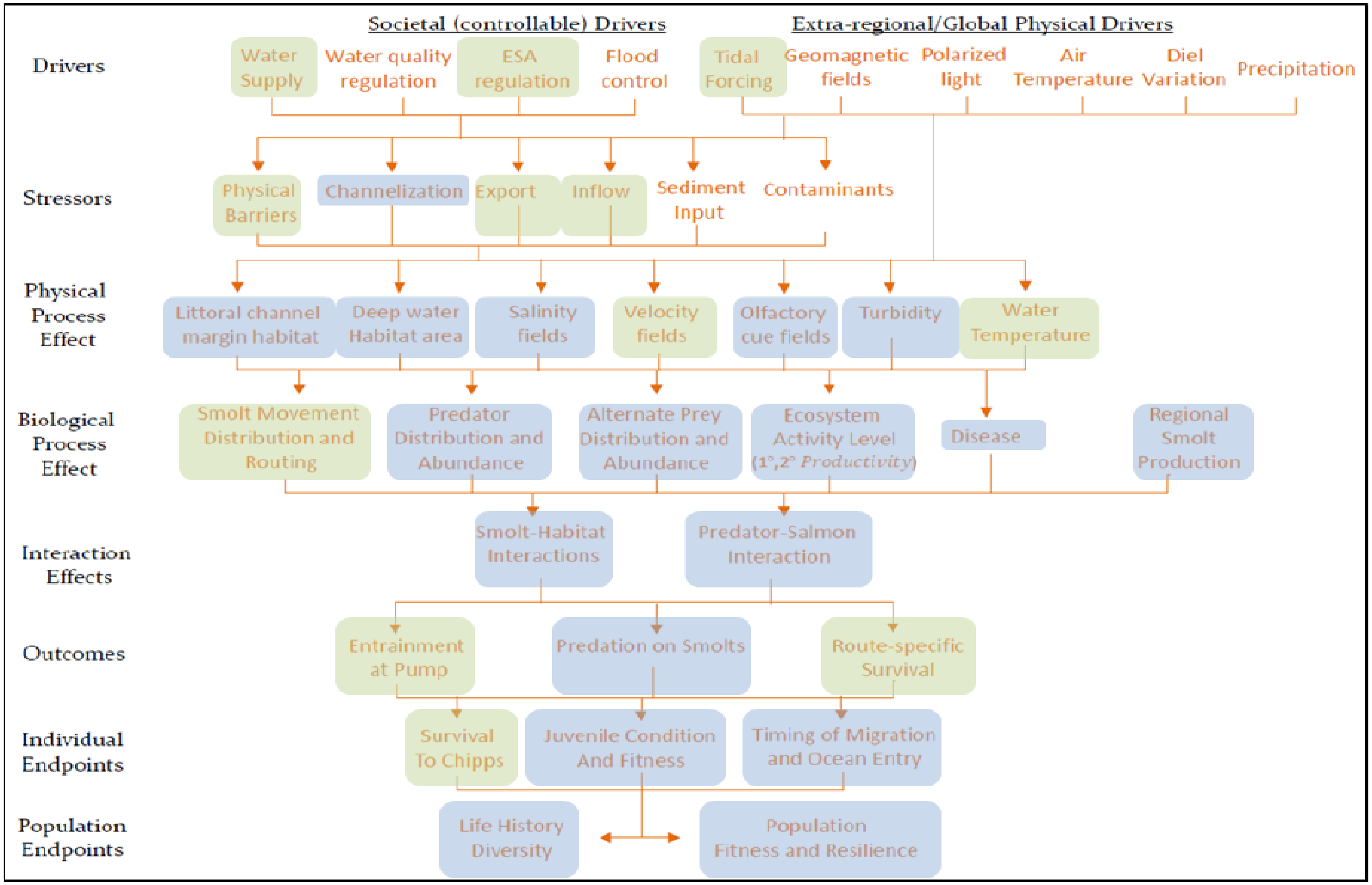


Figure 85. Conceptual model from the South Delta Salmonid Research Collaborative Effort describing factors affecting survival of juvenile salmonids in the South Delta.

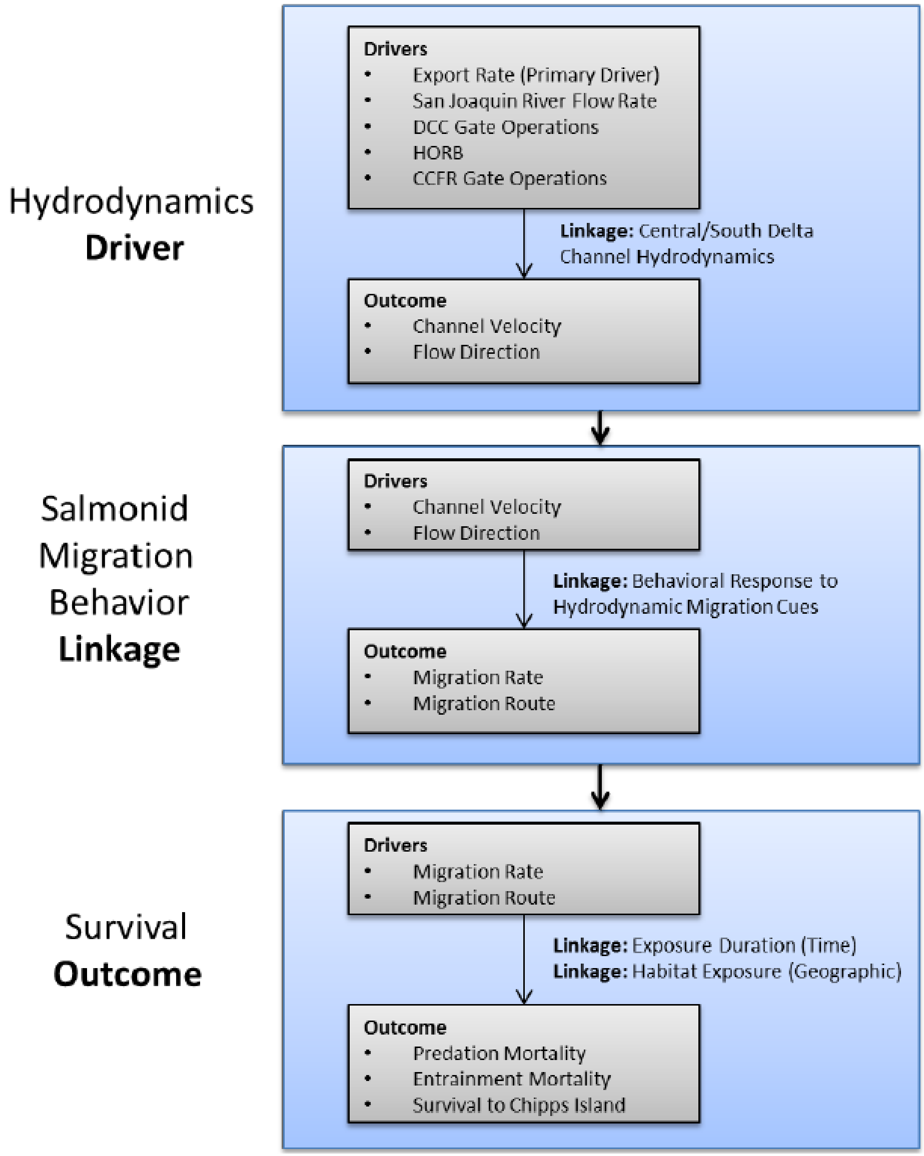


Figure 86. General framework linking hydrodynamic effects of CVP and SWP project operations to migration behavior and survival.

The salmonid scoping team report summarizes recent science relevant to key, but not all, project-related effects (Salmonid Scoping Team 2017a; Salmonid Scoping Team 2017b; Table 50; Table 51; Table 52).

Table 50. Driver-linkage-outcomes analyzed in salmonid scoping team 2017 related to hydrodynamics.

Drivers	Linkages	Outcomes
• Exports • River inflow (Sacramento and San Joaquin) • 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 isoloate 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: Red italics are driver-linkage-outcomes that were not analized

Table 51. 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 herterogeneity of hydrodynamic/water quality drivers • *Small-scale bydrodynamics 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: Red italics are driver-linkage-outcomes that were not analized

Table 52. 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 routs or between years for the same route • Duration of exposure to route-specific conditions that affect survival	• Mortality

Some key assumptions and elements of NMFS's conceptual model 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 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 effect on fish from export facilities have been difficult to detect, but are assumed to effect a greater portion of the population. Velocity and flow changes due 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 withing 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 River on salmonid routing at Turner Cut should not be cited as support for no Old and Middle River 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 model level in the sections immediately below, and 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; and
- Entrainment into the SWP and CVP fish salvage facilities and loss at those facilities.

For an overview of recent science relevant to Delta management, 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 salmonid scoping team convened by the Collaborative Adaptive Management Team (which included technical staff from multiple agencies and stakeholder groups), the report provides an overview of the findings and uncertainties related to salmonids and water operations in the South Delta.

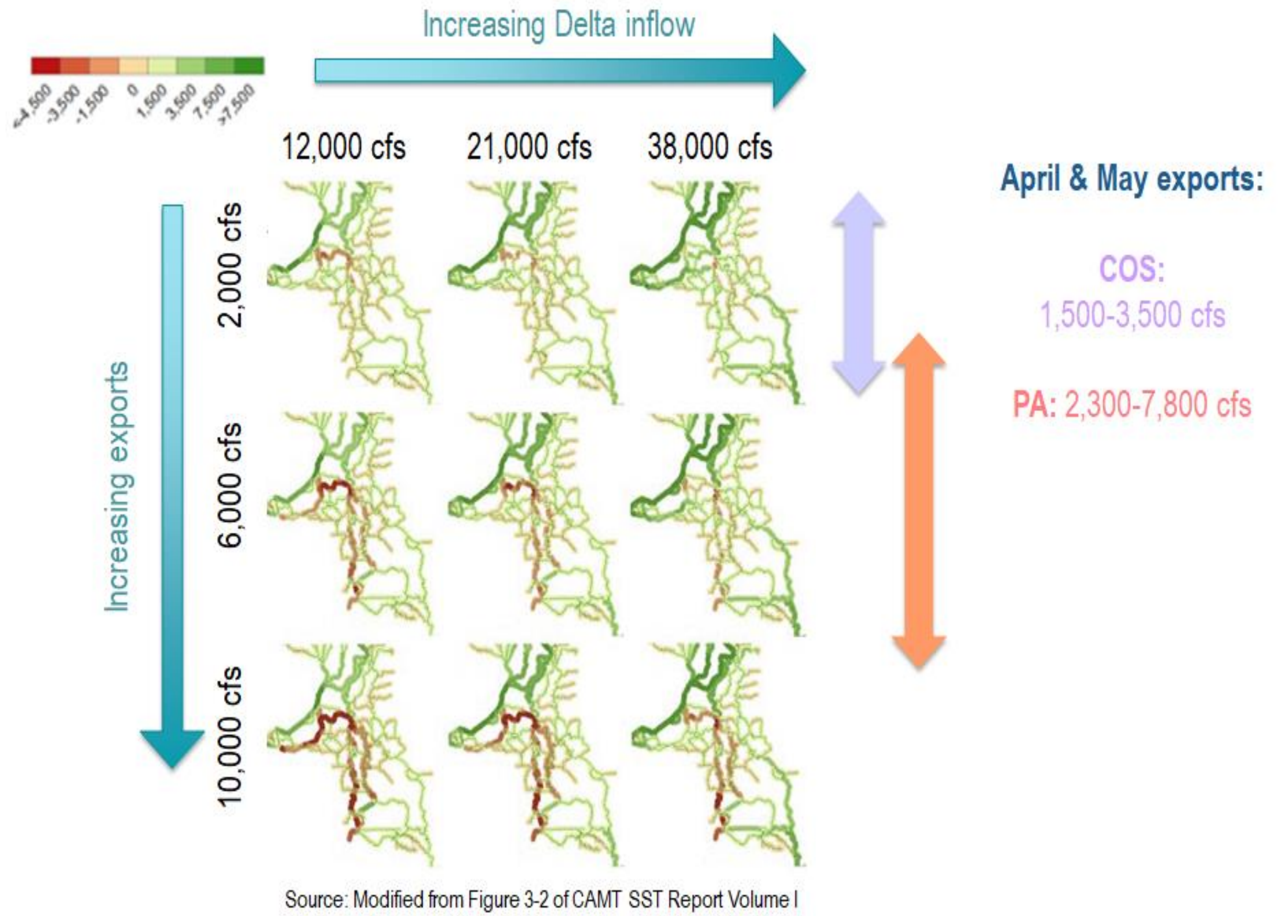
Additional highlights from selected reports and articles are summarized in Appendix H.

8.6.1.1 Routing at junctions on the mainstem Sacramento River and San Joaquin River

Because the routing "decision" occurs at the time the fish reaches the junction, local flow conditions at the time of arrival (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, there is little or no data that can be provided with the available tools at hand in a way that we can evaluate and quantify the specific hydrodynamics at a given junction. In light of the absence of this information, the proportional routing of fish can be 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 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. Our conceptual model assumes that 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. 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. A more detailed discussion of routing is provided in later sections of the opinion (specific to the Delta Cross Channel or Head of Old River junction) and in Appendix B of Volume 1 of the 2017 salmonid scoping team report (Salmonid Scoping Team 2017a).

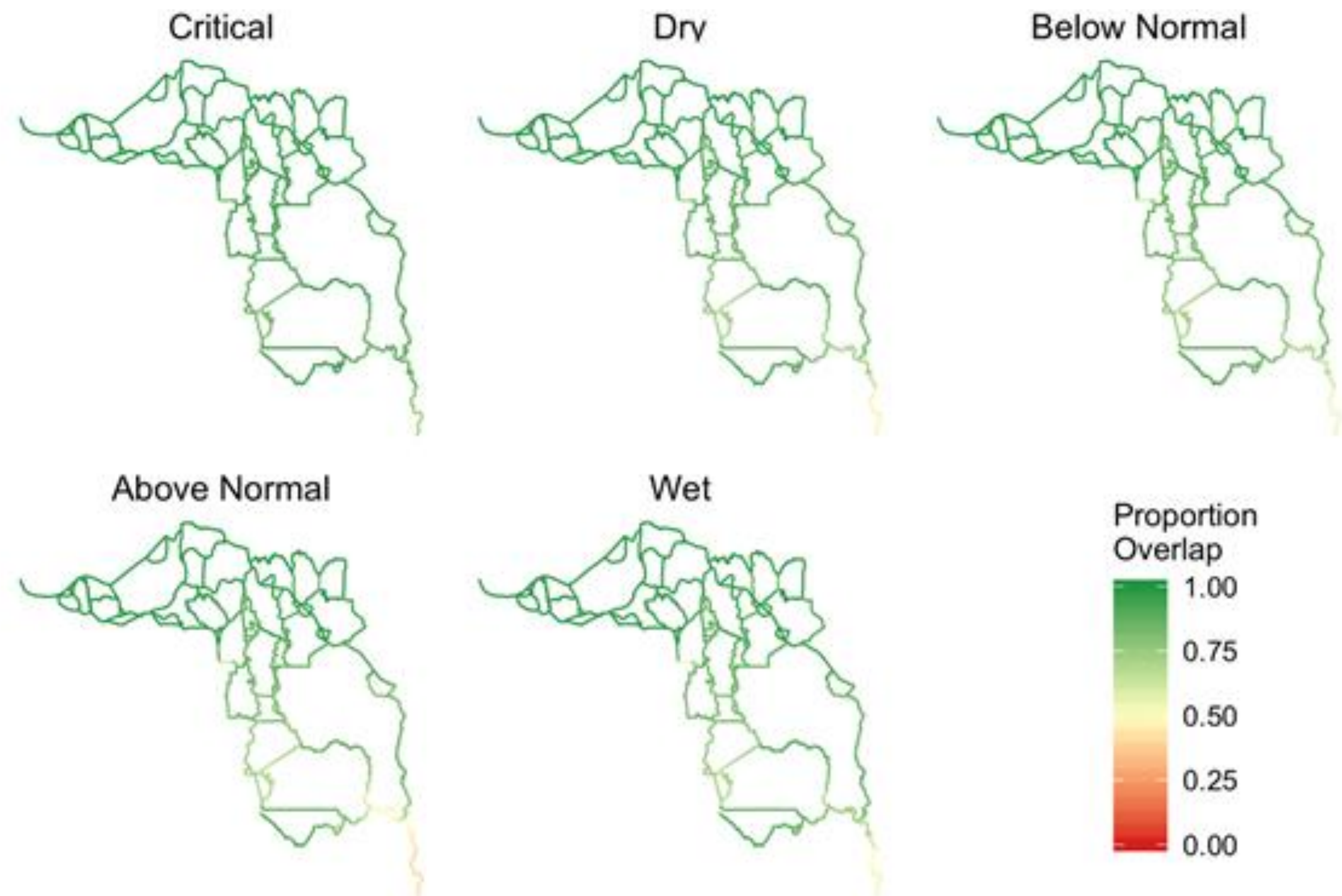
8.6.1.2 Movement and survival in the San Joaquin River and south Delta

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 studies for example, (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. 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. Concern about fish behavior and survival in channels is one important element underlying concerns about minimizing disruptions to South Delta hydrodynamics, which can be influenced by many factors, but primarily 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 project-related components. Examples of how exports and inflow affect South Delta hydrodynamics are shown in Figure 87 below.



Red represents negative (upstream) net flows; green represents positive (downstream) net flows. Export rates were 2,000, 6,000, and 10,000 cfs. Delta inflow rates were 12,000 (10,595 Sacramento River and 1,405 San Joaquin River), 21,000 (18,264 Sacramento River and 2,736 San Joaquin River), and 38,000 cfs (32,288 Sacramento River and 5,712 San Joaquin River). Two-sided arrows indicate the range of modeled monthly exports during April and May for the current operating scenario (purple) and the proposed action (orange). [Source: Modified from Figure 3-2 of (Salmonid Scoping Team (2017a); State Water Resources Control Board (1999)

Figure 87. Heatmap of daily average flows in the Delta modeled in DMS2 under nine scenarios cross-factoring three export rates and three Delta inflow rates.



Source: Figure H-9 of Appendix H of ROC LTO biological assessment

Figure 88. Map of proportion overlap of velocity distributions in the South Delta for the proposed action and current operating scenario scenarios in March through May.

NMFS applied net daily flows as a proxy measure for 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 (for example, at the Old River and Middle River gauge locations used to measure Old and Middle River), NMFS considers a change in net daily flow a useful proxy measure for qualitative, directional changes in the underlying velocity distribution.

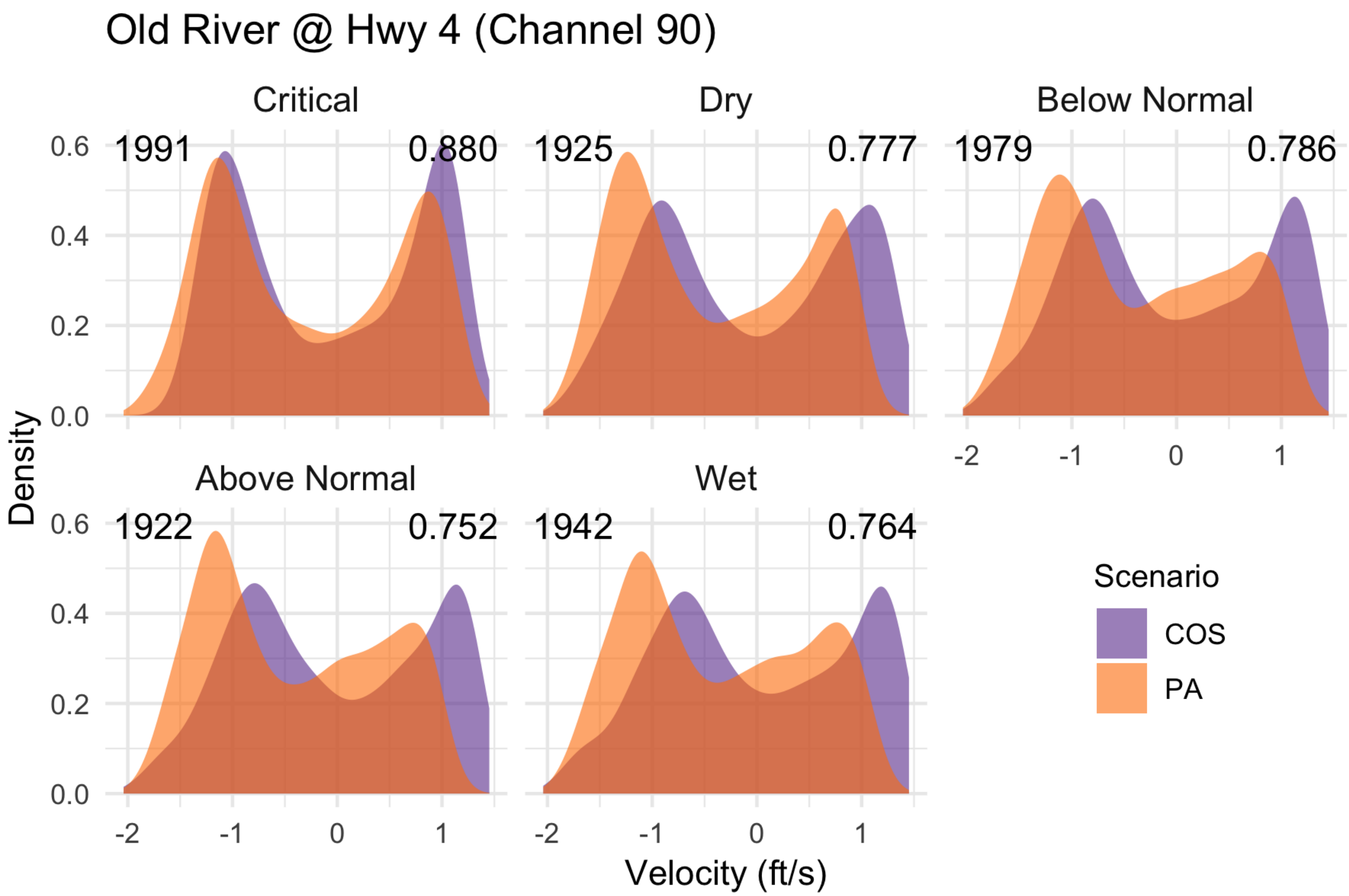
The ROC on LTO biological assessment provided data on both net flows (Old and Middle River flow) and velocity distributions under the current operating scenario (current modeling representation of project operations at the time of consultation) and proposed action. Throughout this effects section, when NMFS refers to effects of net Old and Middle River flow, NMFS is using it as a proxy for the underlying hydrodynamic conditions that mechanistically link to salmonid behavior and survival, 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). Old and Middle River flow is 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.

Effects of exports outside the facilities likely diminish with distance, so net daily flows in the south Delta are expected to be more negative (or less positive) between the export facilities and the Old and Middle River gauge locations, and less negative (or more positive) downstream of the Old and Middle River gauge locations. A change in Old and Middle River flow is expected to be associated with changes (in the same direction, but not necessarily magnitude) in net flows and underlying velocity distributions across this “export effect gradient.” 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, Old and Middle River 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 Old and Middle River metric is a proxy for export change if Vernalis flows are relatively steady. Similarly, if exports are steady, the Old and Middle River metric is a proxy for Vernalis flow change and associated changes in flow on the mainstem San Joaquin River.

Based on the level of exports reported in the current operating scenario and proposed action scenarios in the biological assessment, South Delta hydrodynamics will generally look like scenarios in the top row under the current operating scenario, and like scenarios in the middle row under the proposed action. Since the biological assessment modeling reports monthly export levels, daily export levels under either regime would be expected to have a greater range.

This is an area that needs further study. The 2017 salmonid scoping team report identifies a gap in linking hydrodynamics to in-channel fish behavior -- smaller scale, mechanism-oriented, studies may be necessary (as a complement to measures of through-Delta survival) to better understand how fish react to local conditions.

Appendix H “Bay-Delta Aquatics Effects Figures” of the ROC on LTO biological assessment provides several types of results related to hydrodynamic conditions in the Delta. The “proportion overlap” figures shown for the North Delta and South Delta for three-month periods summarize the overlap of velocity distributions under two paired scenarios. NMFS focused on comparisons between the proposed action and current operating scenario, especially for the period including April and May, when the proposed action is most different from the current operating scenario in the Delta (Figure 88). Because overlaps of more than approximately 50 percent show as green, the distinctions between proposed action and current operating scenario are a bit difficult to discern but one can see that, as expected, the hydrodynamic changes from the increased exports in the March-May period (due primarily to changes in April and May in the proposed action) are greatest in the southernmost Delta near the export facilities and in the Old and Middle River corridor. The change in velocity distributions is more clearly captured in the location specific velocity overlap plots (Figure 89) which show that (again for the March-May period) that the magnitude and frequency of positive, downstream flows, are decreased in the proposed action relative to the current operating scenario.



Source: Supplemental modeling provided in support of ROC LTO biological assessment

Figure 89. Proportion overlap of velocity distributions in the South Delta (Old River at Highway 4; downstream of the export facilities) for the proposed action and current operating scenario scenarios in March through May.

8.6.1.3 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, the bigger picture is that higher exports likely also increase overall entrainment, and modifies hydrodynamic conditions outside of the fish salvage facilities, as discussed above. The SWP has very poor salvage rates compared to the CVP.

Historically, of the four Sacramento River Chinook salmon races, winter-run Chinook salmon have probably been the most vulnerable to entrainment because newly emerged fry would occur in the vicinity of water diversions during the July through August time periods of high agricultural diversion. However, juvenile emigration data suggest that peak winter-run Chinook salmon movement occurs in October and November, when pumping volume is decreasing or has ceased for the season. Fish screens, when meeting specific design criteria for screen materials, sweeping flows, and approach velocities described in the NMFS fish screen criteria (National Marine Fisheries Service 1997a; National Marine Fisheries Service 2011e), have shown guidance efficiencies of greater than 98 percent for juvenile salmonids (i.e., less than two percent entrainment). In a field study of juvenile salmonid injury and mortality related to contact with a vertical profile bar screen at John Day Dam (1.75 mm opening) resulted in an overall average of 2.5 percent for injury and 3.7 percent for mortality (Brege et al. 2005). These results likely represent the high end of juvenile fish injury and mortality rates at vertical profile bar screens.

8.6.1.4 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. 2013; Perry et al. 2010). These studies help to define the relationship of Sacramento River flow (at Freeport) and 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. 2015; Perry et al. 2018; Perry et al. 2010) 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 strong tidal influence. The relationship between flow and survival is in agreement with the assumptions and results of the velocity and entrainment analyses that indicated low, slack, and reverse velocities increase entrainment risk and increase 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 effects of flow changes on through-Delta survival.

NMFS uses three models that predict survival probabilities for smolts that enter the Delta through the Sacramento River Basin: Delta Passage Model, WRLCM using Newman (2003), and Perry et al. (2019). NMFS also incorporated into the Opinion the Salvage Density Model. These models analyze how entrainment loss in the south Delta fish salvage facilities changes under the scenarios, and we also use those analyses to help assess effects on overall south Delta effects.

Perry et al. (2019) and the Delta Passage Model are based on telemetry data which allowed for collection of environmental and hydrological data synchronous with the fate of individual fish as they migrate through the north and central Delta. The equation from Newman (2003) relating exports to survival used in the WRLCM is based on coded-wire tag studies over multiple years and relies heavily on statistical correlation between fish recapture and more broad or generalized environmental/hydrological data.

Delta Passage Model

The Delta Passage Model integrates operational effects of the current operating scenario and proposed action that could influence survival of migrating juvenile Chinook salmon through the Delta. This includes differences in channel flows (flow-survival relationships), differences in routing based on flow proportions (e.g., entry into the interior Delta, where survival is lower), and differences in south Delta exports (export-survival relationships). The Delta Passage Model provides estimates of through-Delta survival for both scenarios over the five water year types, as well as overall survival covering the full 81 years (1923 to 2003) of simulation through DSM2 and CalSimII. The Delta Passage Model estimated through Delta survival for winter-run, CV spring-run, fall-run and late fall-run Chinook salmon.

The Delta Passage Model used 75 iterations of the model for each scenario and reported the mean survival value as well as the 25th and 75th percentile values for each year within the 81 years used in the CalSimII and DSM2 modeling. The Delta Passage Model output conveyed survival as a decimal fraction of survival (i.e., 1.00 is 100 percent survival, and 0.500 is 50 percent survival). For the purposes of this assessment, only the reported mean survival value was used for the comparisons between the proposed action and the current operating scenario scenarios. NMFS compared the two scenarios by taking the difference between reported mean survival values between the proposed action and current operating scenario scenarios for each year within the 81 year period used for the CalSimII and DSM2 modeling; that is, proposed action – current operating scenario= difference in mean survival for each year. The results were summarized for all water years combined for the 81 year period from 1923 to 2003, and by individual water year type, i.e., Wet, Above Normal, Below Normal, Dry, and Critical). The difference reported in the modeling was in absolute decimal fractions (that is 0.50 survival is equivalent to 50 percent survival). Summary statistics were run for each group of results (i.e., all years, and by water year types) and the median value reported for the difference between the proposed action and current operating scenario scenarios. These median values were then reported in Appendix H here as percentages (i.e., a difference of 0.001 decimal fraction in survival is 0.1 percent difference in survival). Finally, relative changes between the current operating scenario and the proposed action were determined by calculating the differences between the median values of the proposed action and current operating scenarios and presenting that value as a percentage of the current operating scenario value (i.e., (PA-current operating scenario/current operating scenario) *100; the percentage difference in relative terms to the current operating scenario value).

Winter-run Chinook Salmon

Overall, winter-run Chinook salmon had the best estimated through-Delta survival of the four different Chinook salmon runs modeled using the Delta Passage Model. The median through Delta survival, as modeled by the Delta Passage Model, was approximately 34 percent for all years simulated for both the current operating scenario and proposed action operations, with only slight differences between the two scenarios. The absolute through-Delta survival was highest in below normal water year types for both scenarios (~45 percent through Delta survival). Based on the differences in through-Delta survival between the two scenarios, the proposed action had slightly better through-Delta survival estimates for Wet, Above Normal, and Below Normal water year types, but was slightly lower than the current operating scenario during Dry and Critical water year types. Over all the years in the modeling simulation, the proposed action was slightly lower in overall median through-Delta survival by 0.070 percent. The absolute differences in modeled median through-Delta survival ranged from approximately +0.009 to -0.24 percent between the proposed action and current operating scenario for each water year type are as follows:

- Wet <0.010 percent (PA greater survival rate)
- Above Normal <0.01 percent (PA greater survival rate)
- Below Normal -0.02 percent (PA lower survival rate
- Dry -0.24 percent (PA lower survival rate)
- Critical -0.21 percent (PA lower survival rate)

Overall, both the absolute and relative differences in through-Delta survival are slight between the proposed action and current operating scenario. The relative difference in survival is less than one percent across all years in the simulation. This is to be expected as the most substantial changes in export levels in the south Delta occur in months when the majority of winter-run Chinook salmon have already migrated through the Delta. Increases in exports during April and May would only affect a small proportion of the emigrating population that is still within the Delta, as most winter-run Chinook salmon have exited the Delta by the end of March, and therefore would not be exposed to the increased export conditions.

CV Spring-run Chinook Salmon

As modeled by the Delta Passage Model, CV spring-run Chinook salmon had a median through-Delta survival rate of approximately 30 percent over the 81 years modeled from the DSM2 and CalSimII simulations, ranging from approximately 20 percent to 52 percent for both scenarios. The median through-Delta survival rate was highest in Wet water year types (~43 percent) for both the current operating scenario and proposed action scenarios. Across all years and water year types, the proposed action had lower median through-Delta survival rates. Across all years in the 81-year simulation period, the median difference between the proposed action and current operating scenario through-Delta survival rate is -0.51 percent. The largest difference between the proposed action and current operating scenario occurred in above normal and below normal water year types. The absolute differences in modeled median through-Delta survival ranged from approximately -0.14 to -0.98 percent between the proposed action and current operating scenario for each water year type are as follows:

- Wet -0.98 percent (PA lower survival rate)
- Above Normal -0.78 percent (PA lower survival rate)
- Below Normal -0.66 percent (PA lower survival rate)

- Dry -0.11 percent (PA lower survival rate)
- Critical -0.14 percent (PA lower survival rate)

The overall changes in through-Delta survival for CV spring-run Chinook salmon is also slight. However, the median proposed action through-Delta survival rate is lower than the current operating scenario in all but Critical water year types, and has a greater absolute and relative percentage change than was observed for winter-run Chinook salmon in the Delta Passage Model modeling. The relative changes in median survival was 1.4 percent lower for the proposed action compared to the current operating scenario. The overlap of the CV spring-run emigration period with the increased exports in April and May are the likely cause for the reduced through-Delta survival rates modeled by the Delta Passage Model.

CV Fall-run Chinook Salmon

The results of the Delta Passage Model for CV fall-run Chinook salmon estimate that the median through-Delta survival is approximately 24 to 25 percent for both the proposed action and the current operating scenario, with the proposed action being slightly lower. The proposed action median through-Delta survival for all 81 years of DSM2 CalSimII simulations included in the Delta Passage Model was 0.32 percent lower than the current operating scenario for the same period. The largest differences between the proposed action and current operating scenario through-Delta survival rates occurred in Wet water year types (1.1 percent lower under the proposed action). The absolute differences in modeled median through-Delta survival ranged from +0.76 to -1.1 percent between the proposed action and current operating scenario for each water year type are as follows:

- Wet -1.14 percent (PA lower survival rate)
- Above Normal -0.95 percent (PA lower survival rate)
- Below Normal -0.09 percent (PA lower survival rate)
- Dry 0.76 percent (PA greater survival rate)
- Critical 0.30 percent (PA greater survival rate)

The overall changes in absolute through Delta survival for CV fall-run Chinook salmon are also slight. The proposed action has better through-Delta survival in Dry and Critical water year types, but then has lower survival in all of the remaining water year types. The overall through-Delta survival rate over the 81-year DSM2 and CalSim II simulation period included in the Delta Passage Model is also less for the proposed action compared to the current operating scenario, and is similar to the rate for winter-run Chinook salmon and CV spring-run Chinook salmon (~0.3 percent lower). Fall-run Chinook salmon emigrate at similar times as young-of-the-year CV spring-run Chinook salmon, and the effects of increased exports during the April and May period would negatively affect both runs.

CV Late Fall-run Chinook Salmon

The Delta Passage Model results for late fall-run Chinook salmon estimate that the median through-Delta survival is approximately 21 to 25 percent for both the current operating scenario and proposed action, with the proposed action consistently lower across all years and by water year type. Over the 81-year DSM2 and CalSimII simulation period included in the Delta Passage Model, the proposed action had a median through-Delta survival rate that was 0.23 percent lower than the current operating scenario. The largest differences between the proposed action and current operating scenario occurred in Wet water year types. The absolute differences in through-Delta survival ranged from -2.02 to -0.08 percent between the proposed action and the current operating scenario for each water year type are as follows:

- Wet -2.02 percent (PA lower survival rate)
- Above Normal -0.08 percent (PA lower survival rate)
- Below Normal -0.15 percent (PA lower survival rate)
- Dry -1.14 percent (PA lower survival rate)
- Critical -0.19 percent (PA lower survival rate)

The overall changes in through-Delta survival are slight. In all water year types and over the 81-year DSM2 and CalSimII simulation period included in the Delta Passage Model, the proposed action has a lower through-Delta survival rate, particularly in Wet water year types where the difference is over 1 percent absolute (7.0 percent relative change). The lower overall survival is likely due to the earlier emigration period for late-fall run Chinook salmon, which spans a broader spectrum of flows in the Sacramento River and export actions in the South Delta during the fall and early winter.

CCV Steelhead

The Delta Passage Model does not model CCV steelhead survival as it is based on the data derived from acoustic tag studies using Chinook salmon. Since the Delta Passage Model is based on Chinook salmon, only a generalized association can be made with CCV steelhead smolts, which are typically larger and have somewhat different behaviors associated with their downstream migration as smolts (Chapman et al. 2013). Delta Passage Model modeling shows that Chinook salmon through-Delta survival is less under the proposed action than under the current operating scenario. Therefore, Delta Passage Model modeling results suggest that CCV steelhead may also more frequently have reduced survival under the proposed action conditions compared to the current operating scenario.

sDPS Green Sturgeon

The Delta Passage Model modeling does not apply to green sturgeon and is not used to assess impacts to survival under the proposed action for any life stage of sDPS green sturgeon.

Winter-run Chinook Salmon Life Cycle Model (WRLCM)

The WRLCM can estimate survival of emigrating winter-run Chinook salmon smolts to Chipps Island that have reared in different habitats within the Sacramento River system, including those that have reared in the Delta. Although not a strict one-to-one comparison, the results of the WRLCM that estimates the survival of smolts rearing in the Delta to Chipps Island under the proposed action and current operating scenario conditions can be compared to the through-Delta survival estimates of the Delta Passage Model in a parallel fashion. Factors which reduce survival (flows, exports, routing into the interior Delta, etc.) are components of both models. The WRLCM estimates that winter-run Chinook salmon smolts that emigrate in January of Wet water year types will have slightly better median survival (3.2 percent) under the proposed action than the current operating scenario. Survival estimates remain higher for the proposed action compared to the current operating scenario in February and March, but are slightly less than January during the Wet water year types. By April and May, the survival under the proposed action is estimated to be less than the current operating scenario, up to 7 percent (absolute) in April, and 3 percent in May. The reductions in survival under the proposed action are likely due to the increases in south Delta exports during these months compared to the current operating scenario conditions, which are modeled using the equations from Newman (2003) relating exports to survival. This reduction in survival during the month of April for winter-run Chinook salmon smolts originating in the Delta holds true for all water year types for the months of April and May, though most winter-run Chinook salmon juveniles have exited the Delta by mid-April. The estimates of survival to Chipps Island for Delta-reared winter-run Chinook salmon smolts is consistently higher for the current operating scenario conditions compared to the proposed action conditions for the remaining water year types. April consistently has the greatest difference in survival between the proposed action and current operating scenario conditions, with up to 9.4 percent difference in below normal years. Overall the proposed action has lower survival rates for winter-run Chinook salmon smolts emigrating to Chipps Island for fish originating in the Delta, except for the period of January through March in Wet water year types. This parallels the general findings of the Delta Passage Model for winter-run Chinook salmon migrating through the Delta, which found reduced survival for the proposed action for Below Normal, Dry, and Critical water year types, and only slightly higher survival for Wet and Above Normal water year types.

Perry Survival Model

The Perry Survival Model (STARs model) combines equations from statistical models that estimate the relationship of Sacramento River inflows (measured at Freeport) on reach-specific travel time, survival, and routing of acoustic-tagged juvenile late-fall Chinook salmon. Given these equations, daily cohorts of juvenile Chinook salmon migrating through the Delta under the CalSim simulations of the proposed action and the current operating scenario were simulated. Daily Delta Cross Channel gate operations from the DSM2 simulations of the proposed action and current operating scenario were also included. Statistical analysis of travel time and survival in eight discrete reaches of the Delta was used for assessing travel time and survival under the proposed action and current operating scenario scenarios. This analysis was based on acoustic telemetry data from several published studies where details of each study can be found (Michel et al. 2015; Perry et al. 2013; Perry et al. 2010). The data for the analysis consisted of 2,170 acoustic tagged late fall-run Chinook salmon released during a 5-year period (2007 to 2011) over a wide range of Sacramento River inflows (6,816 to 76,986 ft^3/s at Freeport). There is the potential that flows outside of this range may not be adequately represented in the model. The model does not use any export-survival relationships, and thus reflects only the influence of Delta inflow, routing, Delta Cross Channel gate operations, and travel time on through Delta survival.

The simulation output for each day was summarized graphically to provide a number of useful statistics for each daily cohort:

- The proportion of fish using each unique migration route.
- The median daily travel time through the Delta.
- The median daily through-Delta survival.
- The probability of entering the interior Delta.
- Daily difference in survival, routing into the Delta interior, and median travel time between the proposed action and current operating scenario.

The difference in daily through-Delta survival between the proposed action and current operating scenario was summarized with graphics that display the distribution of survival differences among the 82 years of the simulation for a given date from October through July. This analysis is unique in that it summarizes daily through-Delta survival of the paired scenarios so it is more realistic of differences in survival that fish would experience under the scenarios on any given day (though it still captures limited variability in flow due to the underlying monthly CalSimII modeling). This is a more realistic representation of effects experienced by outmigrating smolts than the summary statistics used in some of the other methods used in this opinion. Results of the Delta Passage Model and Winter-run Life Cycle Model, for example, provide data summarized over the entire year for each of the 82 years and then summarize those differences collectively and by water year type. This grouping of results can dampen the level of effect that an individual fish may experience at a smaller time scale which may underestimate the actual impact to survival.

To understand how survival differences arise, it is useful to examine how the individual components of migration routing, survival, and travel time contribute to overall survival in a particular year.

Figure 90. Mean daily survival through the Delta simulated for the proposed action and the current operating scenario (middle panel) and difference in the mean daily survival between the proposed action and current operating scenario (bottom panel)., Figure 91, and Figure 92 illustrate detailed model output for 1979, a below normal year water year that exhibited flows ranging from 10,000 cfs to 30,000 cfs in the Sacramento River at Freeport. Delta inflow, specifically Freeport flow, is used as a predictor of survival, travel time, and route entrainment into the interior Delta. When Freeport flows are higher, transit time decreases and through-Delta survival increases.

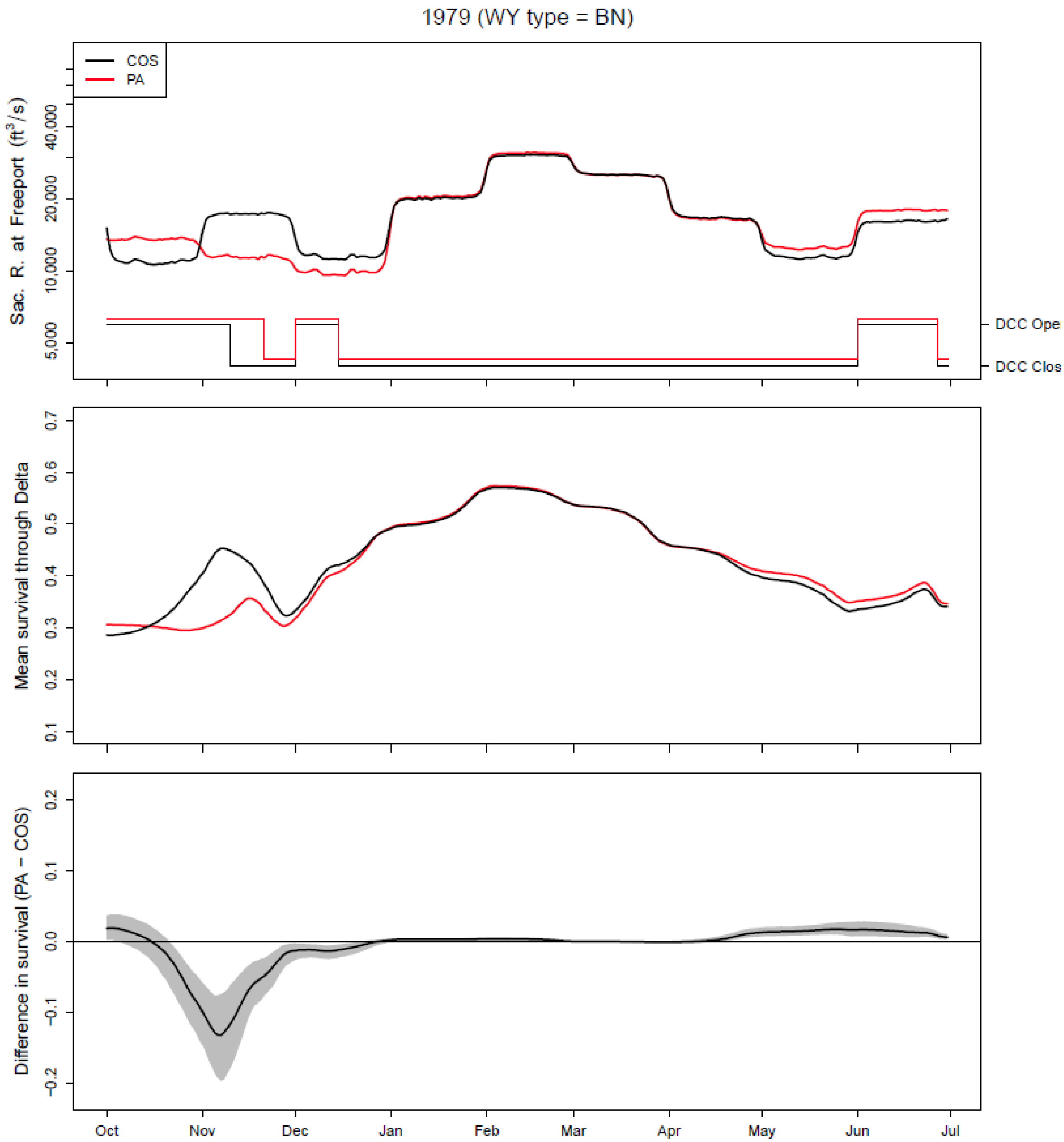


Figure 90. Mean daily survival through the Delta simulated for the proposed action and the current operating scenario (middle panel) and difference in the mean daily survival between the proposed action and current operating scenario (bottom panel). The top panel shows the flows at Freeport on a logarithmic scale for the two scenarios, as well as the operations of the Delta Cross Channel gates (open or closed).

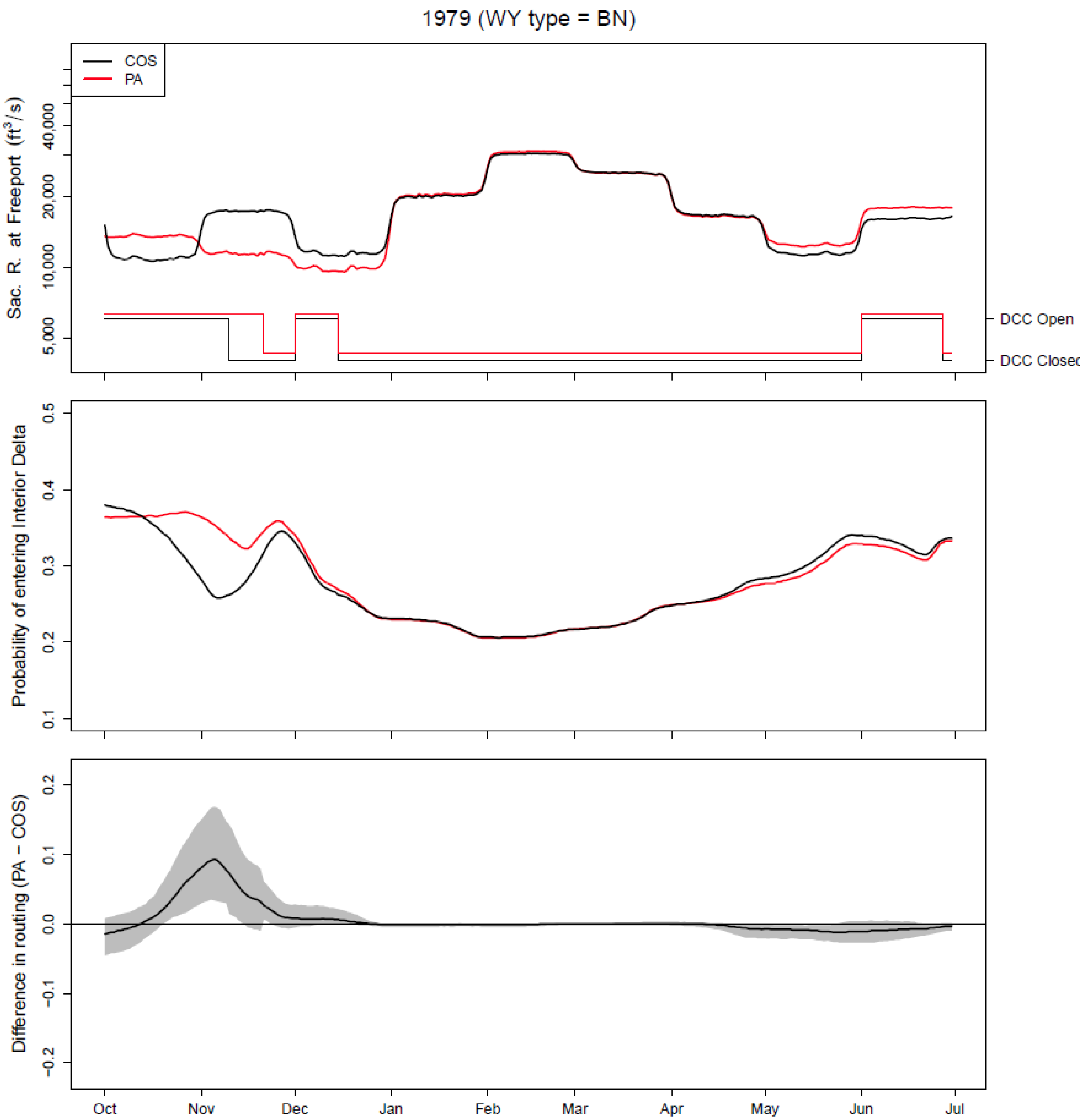


Figure 91. Mean daily probability of entering the interior Delta simulated for the proposed action and the current operating scenario (middle panel) and difference in the mean daily probability of routing into the interior Delta between the proposed action and current operating scenario (bottom panel).

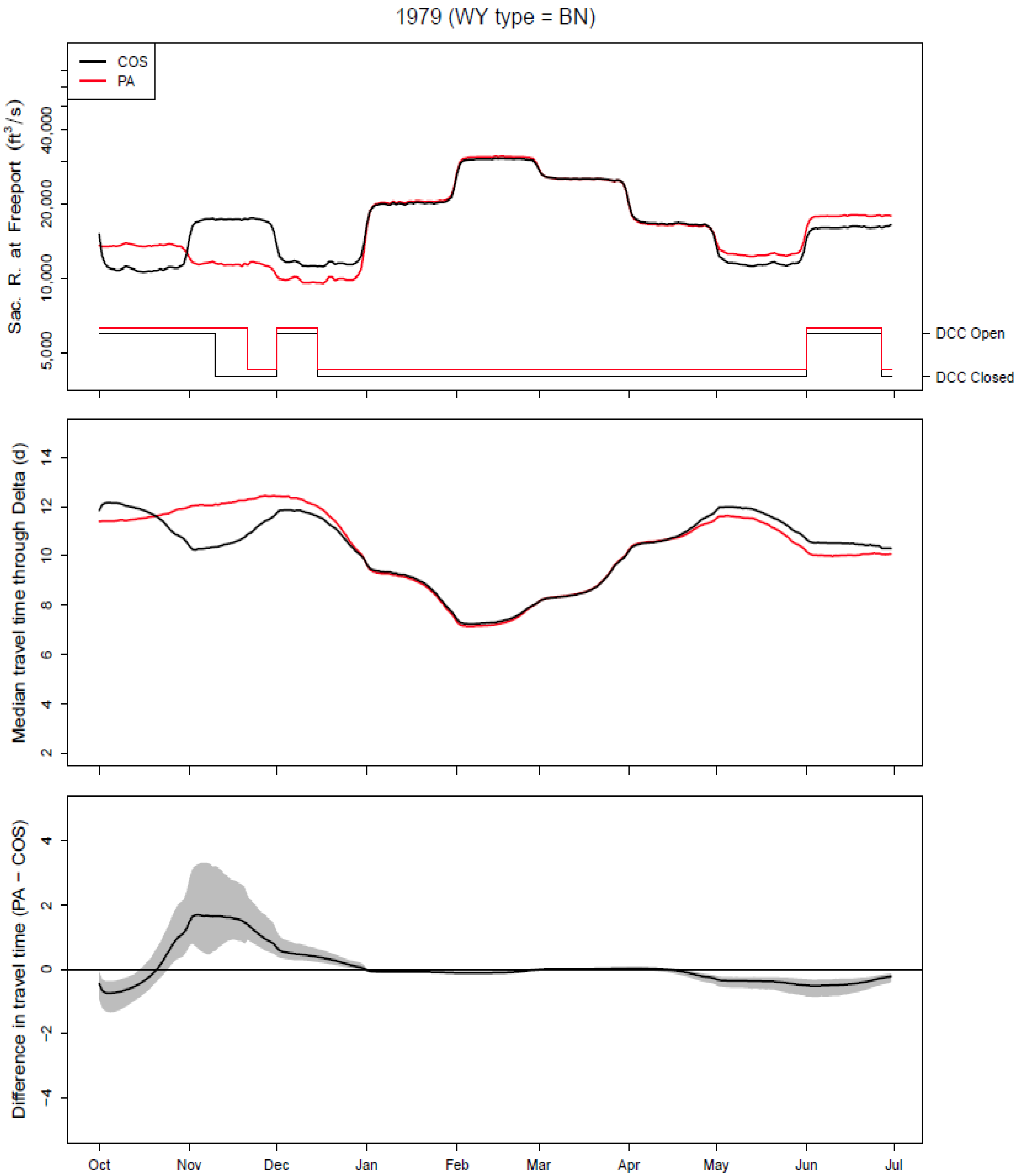


Figure 92. Median daily travel time through the Delta in days simulated for the proposed action and the current operating scenario (middle panel) and difference in the median travel time through the Delta between the proposed action and current operating scenario (bottom panel). The top panel shows the flows at Freeport on a logarithmic scale for the two scenarios, as well as the operations of the Delta Cross Channel gates (open or closed).

When Freeport flows are higher, the probability of entering the interior Delta increases when the Delta Cross Channel gates are open. The modeling of the operations of the Delta Cross Channel gates results in differences between the two scenarios and reflect differences in upstream operations between the two scenarios. Because the model cannot capture Knights Landing catch index or the Sacramento catch index, it uses a flow-based relationship to estimate the number of days when fish are likely to be present. Specifically, the CalSimII model estimates the number of days that the flow at Wilkins Slough would be greater than 7,500 cfs using a relationship derived from historical monthly flows and closes Delta Cross Channel for that many days in a month within the Oct 1 through Dec 14 period. While the model code is exactly the same for the current operating scenario and the proposed action, higher flows at Wilkins Slough result in a greater number of days of closure. Because the current operating scenario scenario includes the 2008 FWS Opinion Fall X2 component in wet and above normal years, flows at Wilkins Slough are higher for the current operating scenario than for the proposed action in those year types, and there are more frequent exceedances of the 7,500 cfs threshold and associated modeled closures of the Delta Cross Channel gates. The proposed action includes a summer fall Delta Smelt habitat action that relies on maintaining X2 during September and October of wet and above normal years primarily through export reductions rather than releases affecting Wilkins Slough results. Therefore, the modeled flows in October and November of wet and above normal years are generally lower under the proposed action and therefore do not trigger closure of the Delta Cross Channel as often (Sumer 2019). In real-time operations, gate closure would be governed by the Knights Landing catch index and the Sacrament catch index and thus may provide equal or better protection than exhibited in the modeling.

This difference in Delta Cross Channel gate operations between the current operating scenario and proposed action is particularly apparent in October and November where through-Delta survival is approximately 45 percent in November for the current operating scenario, compared to approximately 30 percent for the proposed action (Figure 90; middle panel), with a difference in through-Delta survival of about 12 to15 percent (Figure 90; bottom panel). In spring (May through June) the modeled flows at Freeport are slightly higher for the proposed action than for the current operating scenario, which translate into slightly higher through-Delta survival (Figure 83; middle panel), and a slightly positive difference in through-Delta survival of about one to two percent (Figure 90; bottom panel; proposed action is greater than current operating scenario). The responses for routing into the interior Delta and travel time through the Delta reflect the expected responses to changes in Delta inflow and Delta Cross Channel gate position. With the Delta Cross Channel gates open for the proposed action and closed for the current operating scenario, and lower Freeport flows for the proposed action compared to the current operating scenario, there is a higher probability of entering the Delta interior under the proposed action (Figure 91; middle and bottom panels). Conversely, in spring, the Delta Cross Channel gates are closed for both scenarios, but Freeport flow is higher for the proposed action, and thus there is a lower probability of entering the interior Delta for the proposed action compared to the current operating scenario. In Figure 92, higher Freeport flows for the current operating scenario coupled with a closed Delta Cross Channel gate reduces the median travel time through the Delta compared to the proposed action by almost two days in the fall. Conversely in spring, when the proposed action has slightly higher Freeport flows and the Delta Cross Channel gates are closed for both the proposed action and current operating scenario conditions, the proposed action has slightly faster median travel times through the Delta of approximately one day. These general relationships between Delta inflow at Freeport, and the position of the Delta Cross Channel gates are observed throughout the modeled 82 years.

In Figure 93, the boxplots show the distribution of the probability that through-Delta survival for the proposed action scenario is less than survival for current operating scenario over the 82-year period of the modeling for each individual day between October and July. The box plots for each day summarize the data for the 82 years of simulation, with the median depicted as a point in each box, and the box hinges representing the 25th and 75th percentiles. The whisker bars represent the minimum and maximum values over the 82-year period. In fall (October through November), the median point of each boxplot shows that in 50 percent of the years, the probability that the difference between the proposed action and current operating scenario is less than zero is between 60 percent and ~100 percent. By late November – early December, the median probability (50 percent of years) that the difference between the proposed action and current operating scenario is less than zero has fallen to approximately 20 percent. From late December through mid-January, the median probability increases so that in 50 percent of the years, the probability that the through-Delta survival for the proposed action is less than the current operating scenario has risen to nearly70 percent. For the period between February and late March, the median probability (i.e., in 50 percent of years) that the proposed action through-Delta survival is less than the current operating scenario is approximately 20 percent. An additional increase in the probability that the proposed action has a lower through-Delta survival occurs during the first half of April. From late April through June, the probability that in 50 percent of the years that the proposed action has a lower through-Delta survival than the current operating scenario is essentially zero. In summary, the proposed action condition has a high potential to have lower through-Delta survival during three periods of the year: fall (October and November), from mid-December through mid-January, and again in early April.

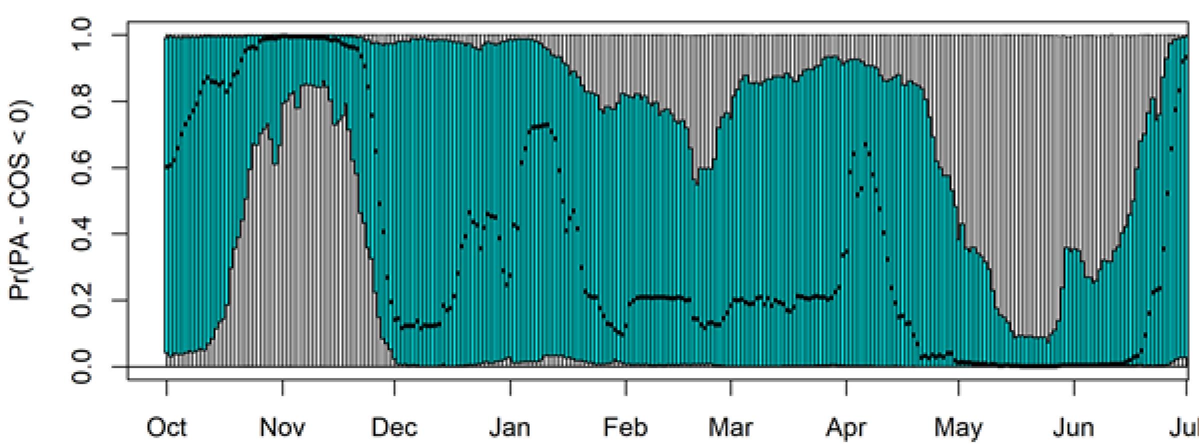


Figure 93. Boxplots showing the distribution of the probability that through-Delta survival for the proposed action scenario is less than survival for current operating scenario. Each box plot represents the distribution among years for a given date of the probability that the difference between proposed action and current operating scenario is less than zero. The point in each box represents the median, the box hinges represent the 25th and 75th percentile, and the whiskers display the minimum and maximum.

The probability that the difference in median travel times through the Delta between the proposed action and current operating scenario conditions is greater than zero is depicted in

Figure 94. This means that travel time is longer for the proposed action compared to the current operating scenario. The box plots for each day summarize the data for the 82 years of simulation as described in the previous paragraph. Similar to the previous figure, the probability that the median travel time is greater for the proposed action compared to the current operating scenario is high for several periods during the year. From October through November, the probability that the difference in median travel times through the Delta between the proposed action and current operating scenario being greater than zero is greater than 60 percent for 50 percent of years modeled. There are two additional large peaks in the probability that the proposed action has longer median travel times during the year, one occurring in January, and the second occurring in April. In contrast, there is little or no probability that the differences between median travel times through the Delta between the proposed action and current operating scenario scenarios are greater than zero from February to April and from late April to mid-June.

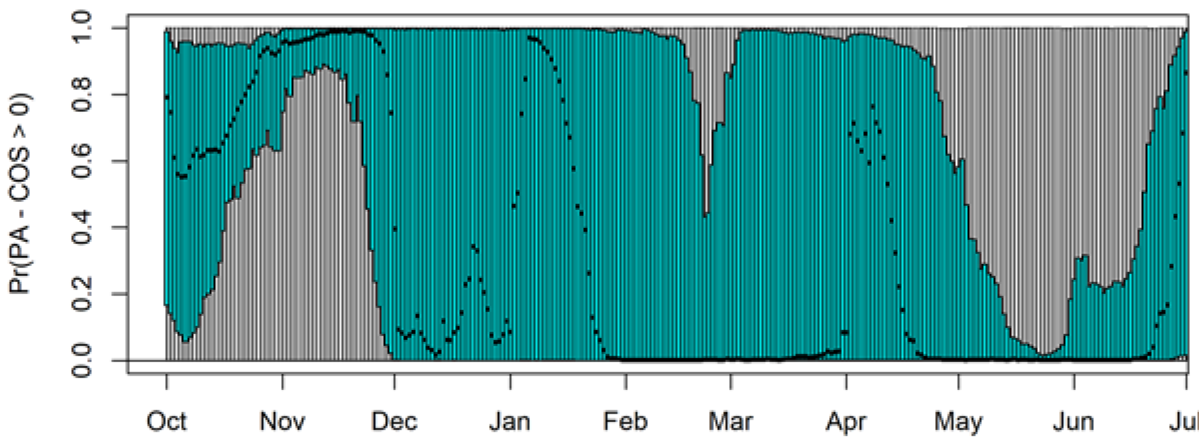


Figure 94. Boxplots showing the distribution of the probability that the difference in median travel time through the Delta between the current operating scenario and proposed action scenario is greater than zero.

Each box plot represents the distribution among years for a given date of the probability that the difference between proposed action and current operating scenario is greater than zero. The point in each box represents the median, the box hinges represent the 25th and 75th percentile, and the whiskers display the minimum and maximum.

Figure 95 depicts the distribution in the probability that the proposed action will have a greater potential to have fish routed into the Delta interior compared to the current operating scenario over the 82-year period of the modeling for each individual day between October and July. The box plots are constructed as previously described. There is a higher probability that from October through November, the proposed action will have a greater potential to route fish into the Delta interior, with 50 percent of the years having up to an 80 percent probability that the difference between the proposed action and current operating scenario will be greater than zero. From December through late May, there is low probability that the proposed action will have a greater potential to route fish into the Delta interior compared to the current operating scenario. This is to be expected as the Delta Cross Channel gates are typically closed during this time for both scenarios. The Delta Cross Channel gates typically open up for the summer starting in June, and the increase in the difference between the proposed action and current operating scenario conditions may reflect operational differences upstream of the Delta under the proposed action rather than Delta Cross Channel gate conditions, as under both scenarios the gates are open.

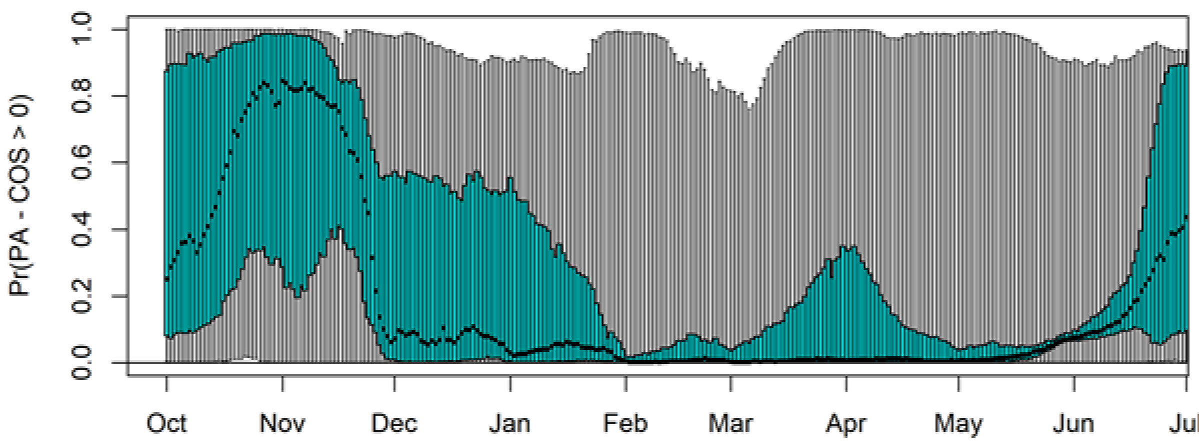


Figure 95. Boxplots showing the distribution of the probability that the difference in routing into the Interior Delta between the current operating scenario and proposed action scenario is greater than zero.

Each box plot represents the distribution among years for a given date of the probability that the difference between proposed action and current operating scenario is greater than zero. The point in each box represents the median, the box hinges represent the 25th and 75th percentile, and the whiskers display the minimum and maximum.

Figure 96 depicts the daily median differences in through-Delta survival between the proposed action and current operating scenario. During the fall period (October through December), through-Delta survival is better under the current operating scenario compared to the proposed action. Differences in survival can range up to 15 percent better under the current operating scenario (whisker bars) but can be approximately 10 percent better in up to 25 percent of the years modeled (25 percent interquartile hinge point). The median difference is slightly less than zero in absolute terms for most of this period, and the 75th percentile is essentially zero from October through November. In December, there is a slight reversal in survival differences (75th percentile quartile is slightly positive, approximately one percent) but the daily median difference of through-Delta survival shows little difference between the proposed action and current operating scenario, essentially tracking the zero line. From mid-April through June there is a slight increase in the difference between the proposed action and current operating scenario, with the proposed action having slightly better (1-2 percent better 75th percentile interquartile) through-Delta survival.

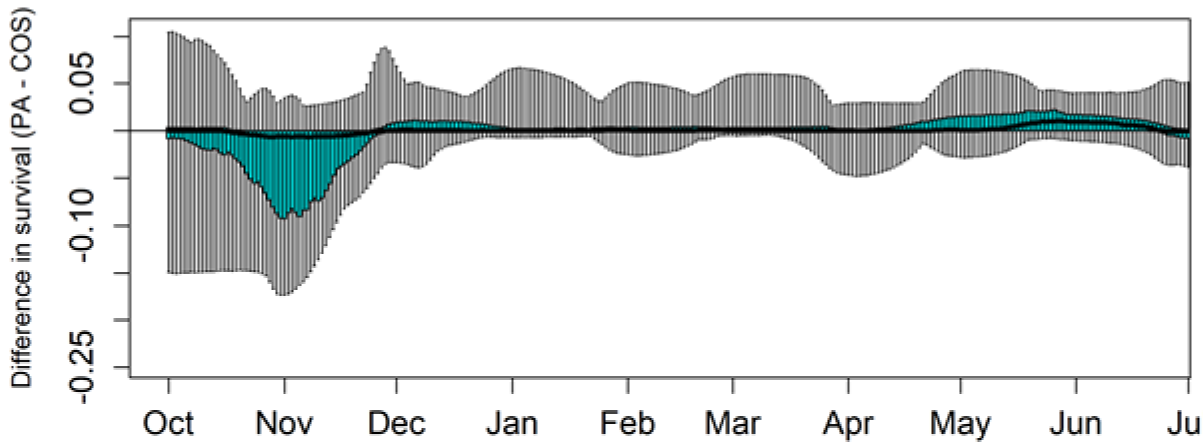


Figure 96. Boxplots of daily median differences in through-Delta survival between the proposed action and current operating scenario scenario.

Each box plot represents the distribution of median survival differences among years for a given date. The point in each box represents the median, the box hinges represent the 25th and 75th percentile, and the whiskers display the minimum and maximum.

Figure 97 and Figure 98 depict the daily differences in median travel time through the Delta and the percentage of fish routed into the Delta interior between the proposed action and current operating scenario conditions for each individual day based on the 82 years in the modeling. The figures show the effect of the changes in Delta inflow and operations of the Delta Cross Channel gate during the fall period (October through November). In response to lower flows in the proposed action and a greater potential for periods of open Delta Cross Channel gates, there is an increase in the median travel time through the Delta for the proposed action and a greater percentage of routing into the Delta interior. This shows up as a positive difference between the proposed action and current operating scenario. The median difference in travel time through the Delta is approximately 0.1 days, but the 75th percentile value can reach up to a difference of 1 day in November. In contrast, the proposed action has faster travel times in the spring (mid-April through June) and the differences are negative (shorter travel time for the proposed action compared to the current operating scenario). The median difference can be as much as half a day faster travel time through the Delta, with the lower 25th percentile values being nearly 1 day in late May and early June. It is not unexpected that the travel time through the Delta is longer in the fall under the proposed action, as the potential to be routed into the Delta interior is also increased during this period. This is a reflection of lower Delta inflows in November under the proposed action and a higher likelihood that the Delta Cross Channel gates will be open compared to the current operating scenario.

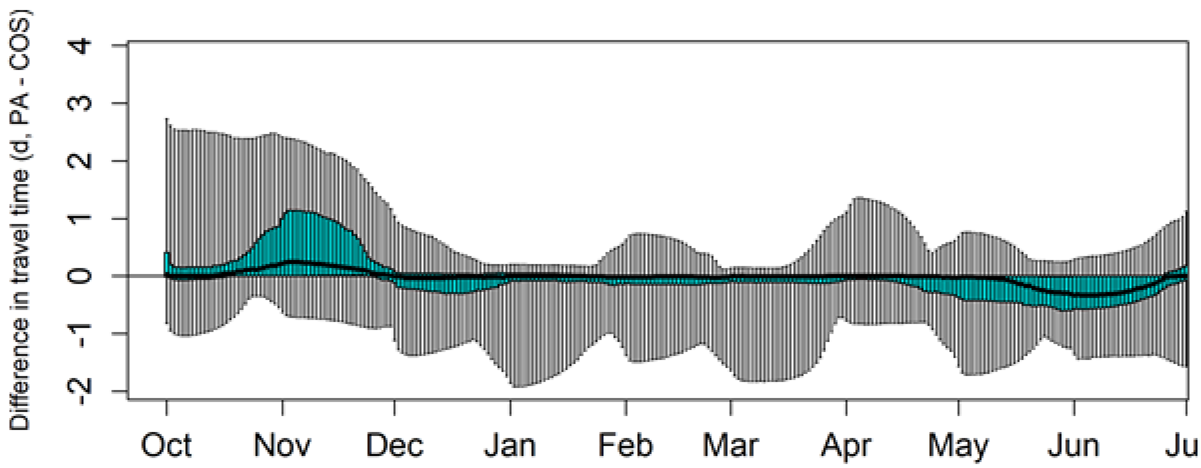


Figure 97. Daily boxplots of median differences in median travel time between the proposed action and current operating scenario scenario.

Each box plot represents the distribution of median travel time differences among years for a given date. The point in each box represents the median, the box hinges represent the 25th and 75th percentile, and the whiskers display the minimum and maximum.

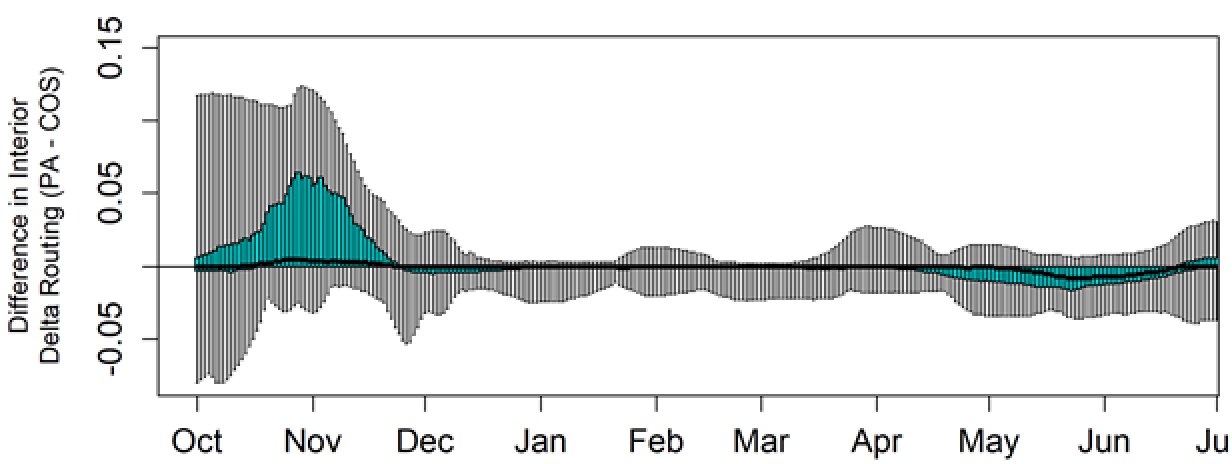


Figure 98. Daily boxplots of median differences in routing to the Interior Delta betwen the proposed action and current operating scenario scenario.

Each box plot represents the distribution of median routing differences among years for a given date. The point in each box represents the median, the box hinges represent the 25th and 75th percentile, and the whiskers display the minimum and maximum.

The box plots in Figure 99 depict the differences in through-Delta survival between the proposed action and current operating scenario by water year type. In each of the water year types, the proposed action has a greater potential to have lower through-Delta survival in the fall. The median values of the differences are little different than zero, however the 25th percentile values indicate that differences in survival may range up to 10 percent less for the proposed action than the current operating scenario. There is less difference in critical years compared to the other four water year types. For the remainder of the year (December through June) there is little difference in the through-Delta survival between the proposed action and the current operating scenario. In wet years there is a small increase (~1 percent) in survival under the proposed action scenario compared to the current operating scenario in December. There are also similar increases in below normal and dry water year types during this December period, but the magnitude is much smaller. As seen previously, there is also a small increase in through-Delta survival under the proposed action conditions in the spring, centered on May and June, but it is very small in magnitude (< 1 percent).

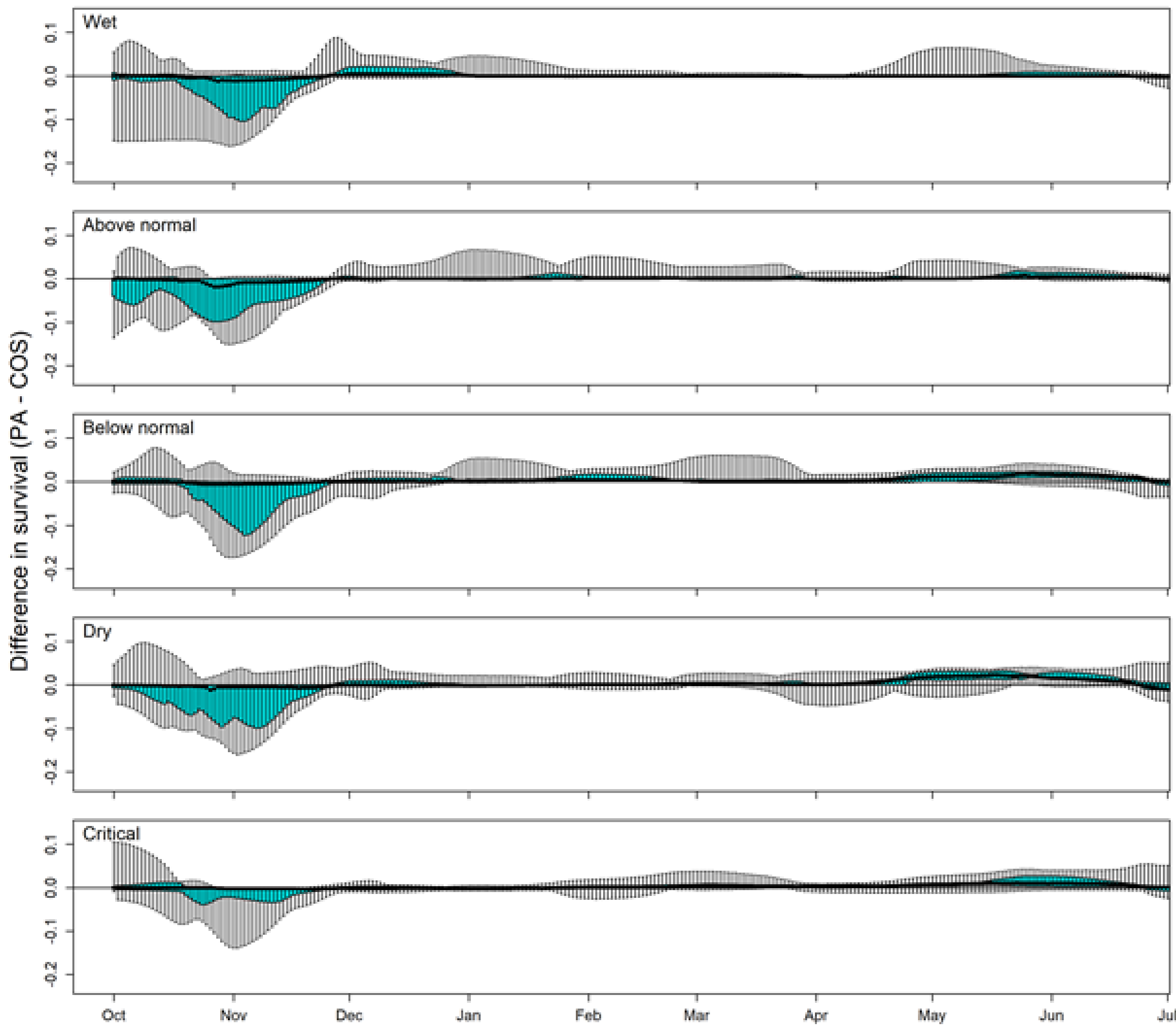


Figure 99. Daily boxplots of median differences in median through-Delta survival between the proposed action and current operating scenario scenario by water year type.

Each box plot represents the distribution of median survival differences among years for a given date. The point in each box represents the median, the box hinges represent the 25th and 75th percentile, and the whiskers display the minimum and maximum.

The box plots in Figure 100 depict the differences in median travel time between the proposed action and current operating scenario conditions by water year type. In all water year types, there is an increase in the median travel time difference between the proposed action and current operating scenario in the fall period (October through November) indicating that the travel time in the proposed action is longer than the current operating scenario. The peak difference between the proposed action and current operating scenario during the fall occurs in early November. The 75th percentile values for the wet, above normal, below normal, and dry water year types are approximately one day longer for the proposed action than the current operating scenario during this period. The difference in critical water years is slightly less. In wet water years, the proposed action has slightly shorter travel times than the current operating scenario in December, which is also reflected by the increased through-Delta survival for the proposed action during this period. During the remainder of the year, but particularly in the spring period, there are periods in which the proposed action has reduced travel times compared to the current operating scenario. From December through May, these reductions in through-Delta travel times are typically slight. Larger reductions in the through-Delta travel times for the proposed action compared to the current operating scenario are seen in May and June.

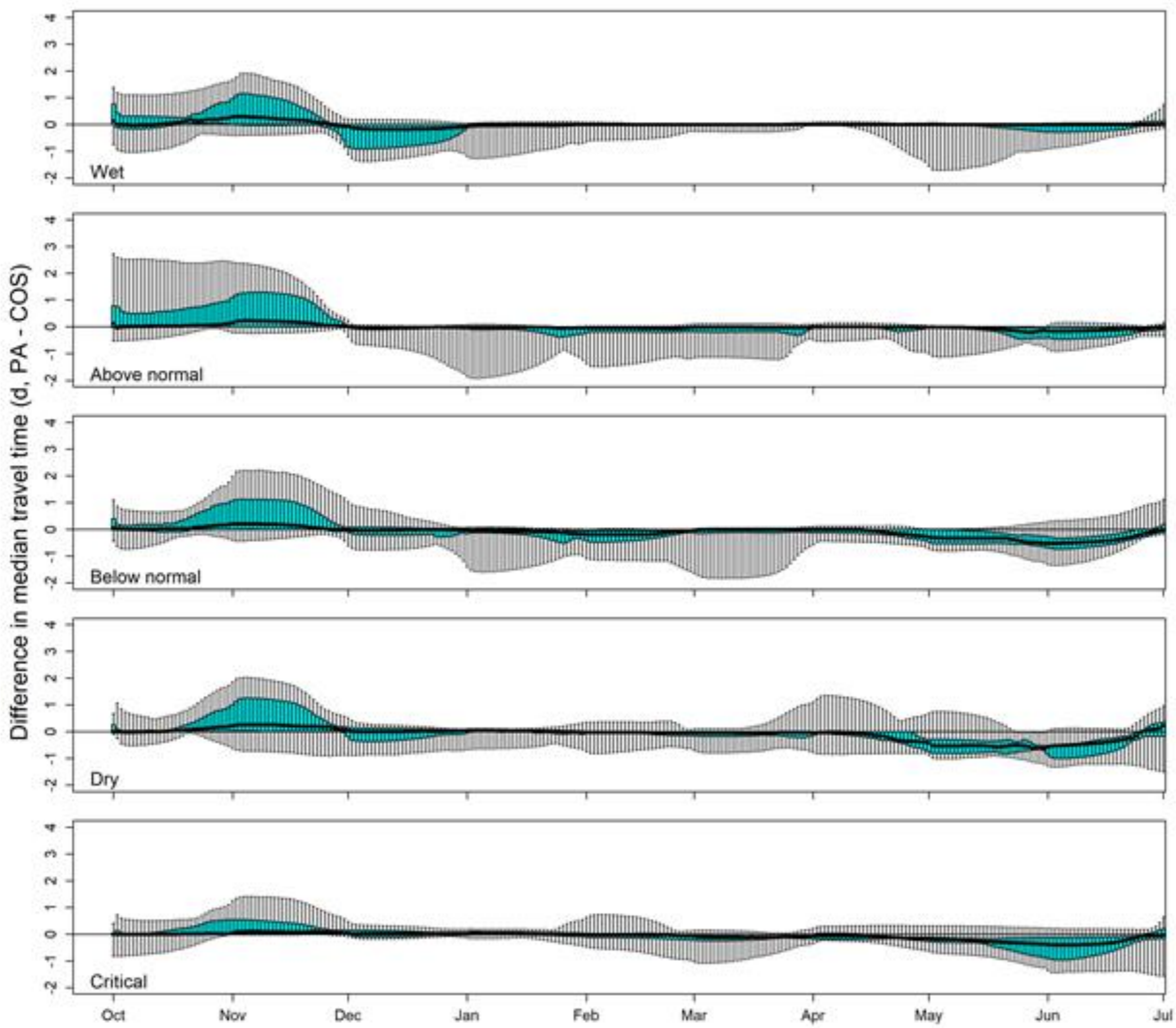


Figure 100. Daily boxplots of median differences in median travel time between the proposed action and current operating scenario scenario by water year type.
Each box plot represents the distribution of median travel time differences among years for a given date. The point in each box represents the median, the box hinges represent the 25th and 75th percentile, and the whiskers display the minimum and maximum.

The box plots in Figure 101 depict the daily median differences in the interior routing between the proposed action and current operating scenario conditions by water year type. In each water year type, there is a higher likelihood that a greater percentage of fish will be routed into the Delta interior during October through November under the proposed action scenario than under the current operating scenario. While the median value of the differences between the proposed action and current operating scenario is typically little different than zero, the 75^{th} percentile of the box plot indicates that the proposed action can be 5 to 10 percent higher in routing fish into the Delta interior during this period. This is expected given the lower Delta inflows for the proposed action during this period and the greater likelihood that the Delta Cross Channel gates are open. The difference between the proposed action and current operating scenario routing is less in critical water year types compared to the other water year types. As expected, during the spring, when the proposed action tends to have slightly better inflows to the Delta, the percent of fish routed into the Delta interior is slightly lower for the proposed action compared to the current operating scenario.

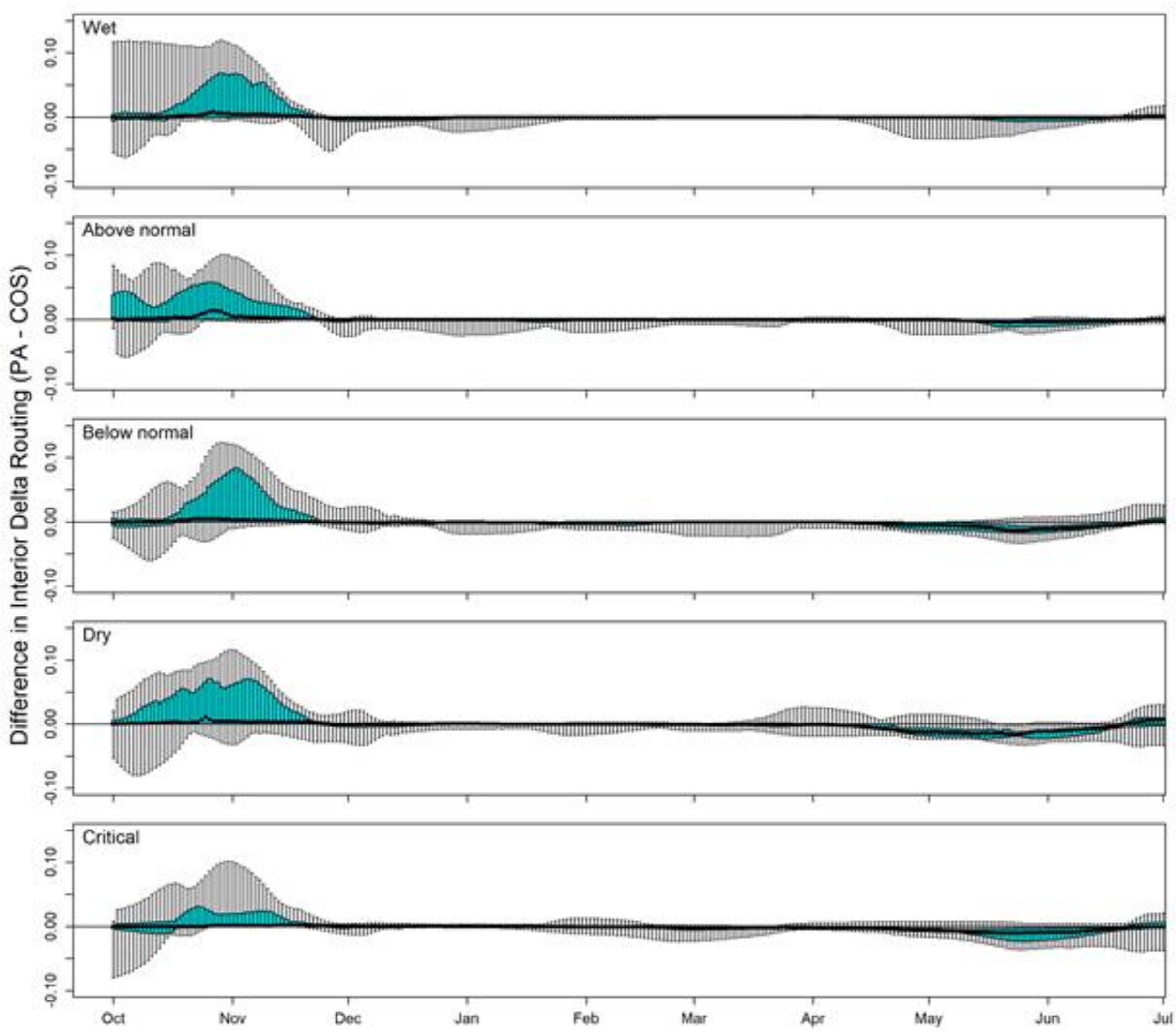


Figure 101. Daily boxplots of median differences in interior Delta routing between the proposed action and current operating scenario scenario by water year type.

Each box plot represents the distribution of median routing differences among years for a given date. The point in each box represents the median, the box hinges represent the 25th and 75th percentile, and the whiskers display the minimum and maximum.

Winter-run Chinook Salmon Exposure and Risk

The Perry Survival Model comprehensively looks at factors that affect survival, such as travel time, routing into the Delta interior, and operations of the Delta Cross Channel gates, to evaluate how changes in Delta inflow will affect smolt migratory success between the proposed action and current operating scenario scenarios. Since daily results are segregated by month and then further by water year type, we can thoroughly examine the exposure and risk associated with these changes for winter-run Chinook salmon smolts.

The main migratory period for winter-run Chinook salmon juveniles is October through April. Based on the modeling outputs, juvenile winter-run entering the Delta from the Sacramento River in October or November will have a greater risk of being routed into the Delta interior through open Delta Cross Channel gates associated with lower Delta inflows under the proposed action compared to the current operating scenario. These routes have the potential to have longer travel times through the Delta for the proposed action compared to the current operating scenario, which in turn is expected to create conditions that have lower through-Delta survival for migrating winter-run Chinook salmon. Based on the modeling, survival could be reduced up to approximately 10 percent (lower 25th percentile) during the October through November period in wet, above normal, below normal, and dry years. In critical years, the reduction is less. This would affect approximately 5 percent of the brood year population based on historical fish monitoring. In wet years, higher Delta inflows in December under the proposed action, coupled with closed Delta Cross Channel gates would provide a small improvement in through-Delta survival for winter-run emigrants entering the Delta. Increased flows reduce travel times and the potential for routing into the Delta interior at other junctions (i.e., Georgiana Slough). This would benefit approximately 10 to 25 percent of the winter-run brood year population which enter the Delta during December. For the rest of the juvenile winter-run Chinook salmon migration period (January through April) the modeling shows little difference in through-Delta survival and routing into the Delta interior, and very minor improvements in through-Delta travel times. Overall, the proposed action is expected to negatively affect approximately 5 percent of the annual brood year population that may potentially emigrate into the Delta in October or November. Positive survival effects are likely to occur only in wet years during December, to approximately 10 to 25 percent of the annual brood year population emigrating into the Delta.

CV spring-run Chinook salmon Exposure and Risk

The main migratory period for CV spring-run Chinook salmon juveniles is December through May. Older yearling CV spring-run Chinook salmon are expected to start emigrating into the Delta starting in October and continuing through January and into February. Like juvenile winter-run Chinook salmon, yearling CV spring-run Chinook salmon will be exposed to the higher risks of being routed into the Delta interior through open Delta Cross Channel gates. The open gates are associated with lower Delta inflows under the proposed action as compared to the current operating scenario. Fish following these routes will potentially have longer travel times through the Delta under the proposed action compared to the current operating scenario. Longer routes are associated with conditions that may lead to a reduction in through-Delta survival under the proposed action. This is expected to occur in all water year types (), however the reduction will be a lower in critical water year types. Like juvenile winter-run Chinook salmon, yearling CV spring-run Chinook salmon that emigrate into the Delta in December of wet water year types will likely see better conditions and have higher through-Delta survival. This is in part due to the higher forecasted Delta inflows in December of wet years, coupled with closed Delta Cross Channel gates reducing routing into the Delta interior. Increased flows reduce travel times and the potential for routing into the Delta interior at other junctions (i.e., Georgiana Slough).

Very few juvenile CV spring run Chinook salmon would be present emigrating to the Delta prior to January. From January through the beginning of April there is very little difference between the through-Delta survival rate for the proposed action and current operating scenario. Improvements in the proposed action through-Delta survival rate begin to occur in mid-April when the difference between the proposed action and current operating scenario becomes positive. This indicates that the proposed action has better survival than the current operating scenario, although the magnitude of improvement is fairly small (approximately 1 to 2 percent at the 75th percentile level). Part of this improvement is due to higher levels of Delta inflow proposed for the proposed action. Based on historical monitoring, the last 50 percent of the annual brood year of CV spring-run Chinook salmon would be moving into the Delta during April and May. These fish would be exposed to the better through-Delta survival rates found in the mid-April through June period under the proposed action and would be expected to benefit from the improved conditions.

CCV Steelhead Exposure and Risk

The Perry Survival Model does not model CCV steelhead survival and movements as it is based on data derived from studies using acoustic tagged Chinook salmon in the Delta. Given that steelhead and Chinook salmon have generally similar, but not identical migratory behaviors, only a generalized association can be made.

CCV steelhead smolts are present within the Delta in most months of the year but the main migratory season for smolts to move through the Delta is from November through June. It is reasonable to assume that CCV steelhead smolts emigrating through the Delta at the same time and under the same conditions assumed for the Perry Survival Model for Chinook salmon would experience the same Delta inflows, Delta Cross Channel gate operations, and hydraulic conditions at river junctions. The magnitude of response by CCV steelhead smolts may be different, but the general trends should be similar. For CCV steelhead smolts emigrating in the fall period during October and November, there is an increased likelihood that more fish will be entrained into the Delta interior through open Delta Cross Channel gates under the proposed action as compared to the current operating scenario. Fish that do so will have longer travel times through the Delta interior and more than likely have reduced through-Delta survival. Only a small proportion of the emigrating population of CCV steelhead smolts is expected to be present in the Delta during October and November. From December through April, there would be little difference between the proposed action and current operating scenario regarding routing and travel times, and therefore through-Delta survival should not vary much between the two scenarios. This is the period in which 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 steelhead from the Sacramento Basin have already emigrated.

sDPS of North American Green Sturgeon

The Perry Survival Model does not apply to sDPS green sturgeon and is not used to assess impacts to survival under the proposed action for any life stages of sDPS green sturgeon.

Summary

Based on the results of the Perry Survival Model, winter-run Chinook salmon juveniles and yearling spring-run Chinook salmon are the two groups of salmonids that will be affected most by the proposed action. Those fish that migrate through the Delta during October and November will see the largest differences in through-Delta survival, routing into the Delta interior, and travel times. Based on the results of the modeling for the October and November period, the proposed action will decrease through-Delta survival compared to the current operating scenario, increase the number of fish routed into the Delta interior compared to the current operating scenario, and increase the through Delta travel time of fish compared to the current operating scenario. It should be noted that these differences are driven in part by the operations of the Delta Cross Channel gates, which respond to the differences in river flow between the two scenarios as described above. Operations of the gates in real time, based on observations of fish in monitoring programs, may differ from the operations of the gates in the modeling, and thus provide equal or better protection than exhibited in the modeling. Finally, since the Perry Survival Model does not use any specific relationships between exports and survival, the model is relatively insensitive to the effects of changing exports. Likewise, the Perry Survival Model does not specifically use any data from studies conducted in the San Joaquin River side of the Delta, and therefore should not be used to interpret survival, routing, or travel times for salmonids entering the Delta from the San Joaquin River side of the Delta.

8.6.2 Presence of the Species within the Bay – Delta Division

The approach used for this analysis was to identify which ESA-listed species would likely to be present in the Bay-Delta Divion and exposed to the proposed action-related stressors. NMFS conducted a review of nearby CDFW and FWS monitoring locations, run timing, and fish salvage data to determine the likelihood of ESA-listed fish presence (Table 7, Table 10, Table 12 and Table 14). Adult salmonids typically migrate through the Delta within a few days. Juvenile Chinook salmon spend from three days to three 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.

The Bay-Delta waterways function primarily as migratory corridors for 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. Green sturgeon use the area for rearing and migration year-round. Generally, as flows increase in the fall and through the winter, adult 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 winter-run Chinook salmon typically migrate through the estuary/Delta from November to June with the peak occurring in March (Table 7). Adult CV spring-run Chinook salmon migrate through the Delta from January to June (Table 10), with a peak presence from February to April (Table 10). 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 (Table 12). Adult sDPS green sturgeon start to migrate upstream to spawning reaches in February and their migrations can extend into July (Table 14), but may also be found holding in waters of the Sacramento River basin and Delta year-round.

8.6.2.1 Sacramento River Winter-run Chinook Salmon

Adult 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 (Table 7) 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. Winter-run Chinook salmon adults 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 main stem Sacramento River upstream of the Delta, including the Yolo Bypass when inundated.

For juvenile winter-run Chinook salmon, a review of fish monitoring data from 2000 to 2016 from the Chipps Island trawl and the Sacramento River trawl (Sherwood Harbor) showed very low numbers present from July through October (Barnard et al. 2015; Miller et al. 2017; Speegle et al. 2013; University of Washington Columbia Basin Research 2019; FWS DFJMP data 2000 to 2016 (U.S. Fish and Wildlife Service 2019); Figure 13 and Figure 14). Juvenile winter-run Chinook salmon occur in the Delta primarily from November through early May with a peak occurrence in March, using length-at-date criteria from trawl data in the Sacramento River near Sherwood Harbor (Speegle et al. 2013; Barnard et al. 2015; Miller et al. 2017; Table 7).

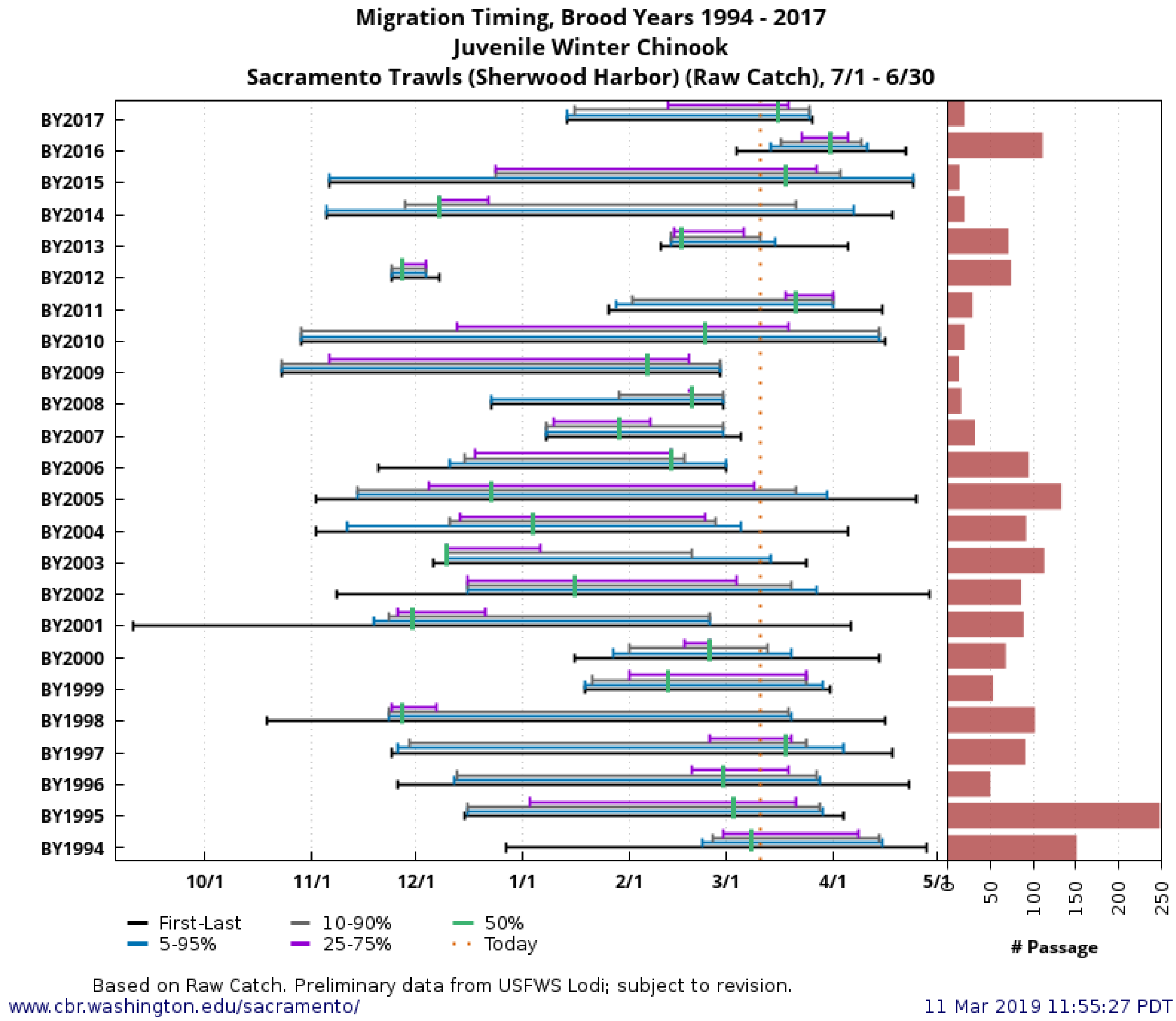


Figure 102. Juvenile winter-run Chinook salmon migration timing past the Sherwood Harbor - Sacramento Trawl location for brood years 1994 to 2017.

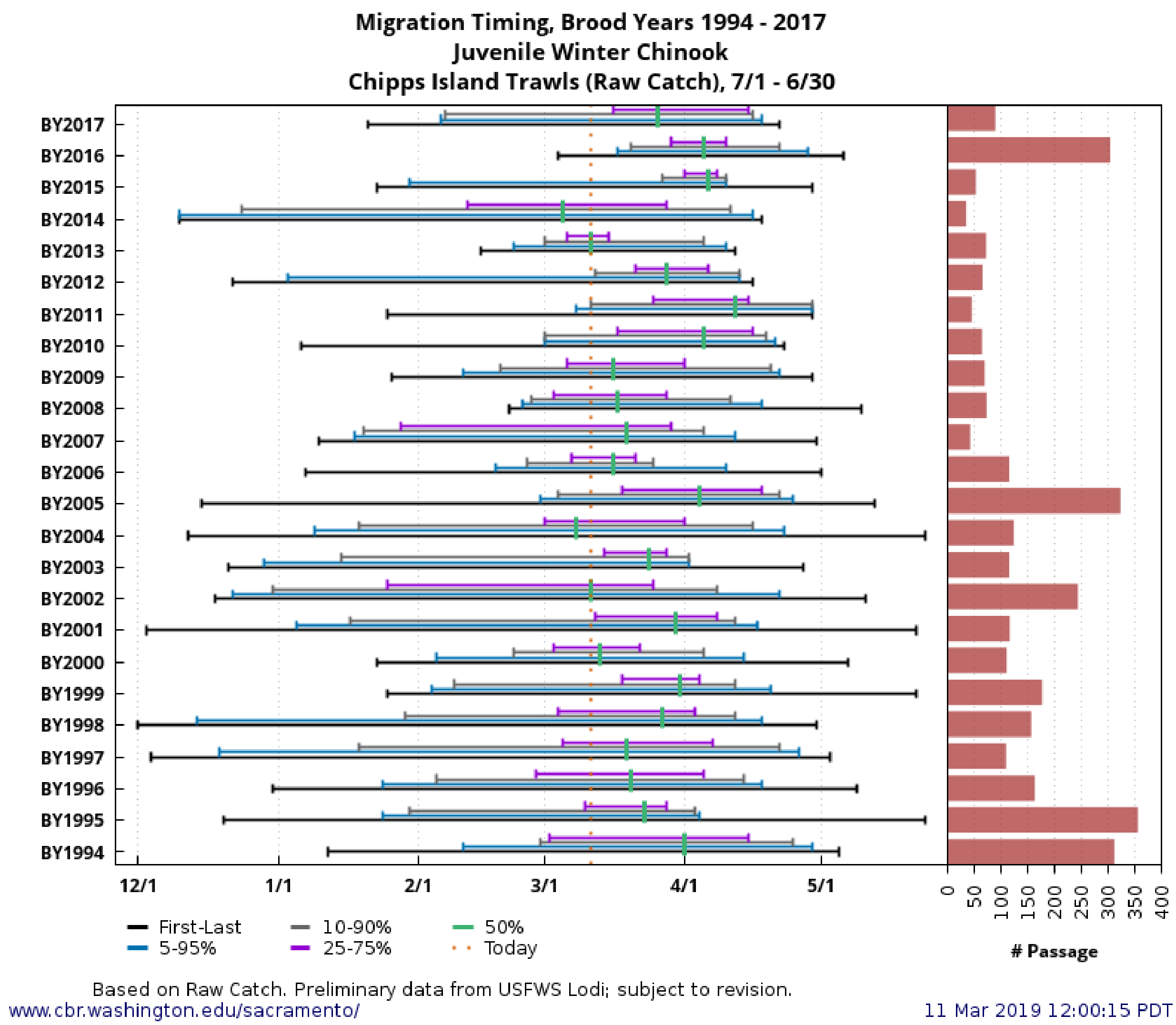


Figure 103. Juvenile winter-run Chinook salmon migration timing past the Chipps Island Trawl location for brood years 1994 to 2017.

There are no reported populations of 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 be stray into the channels of the Central Delta north of the main stem San Joaquin River as they try to regain access to the main stem 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. 2013; Perry et al. 2012; Perry et al. 2010; Romine et al. 2013), substantial fractions of the emigrating juvenile 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 as well as 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 that juvenile winter-run Chinook salmon are moving through alternate routes, they may utilize the Delta for rearing. A study by del Rosario et al. (2013) found that 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 Old and Middle rivers, as well as other channel junctions in this reach, rather than moving towards the western Delta. Juvenile 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 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 (Old and Middle rivers) leading to the export facilities due to the diversion of water at these facilities, juvenile winter-run 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 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 Central Valley 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 winter-run Chinook salmon.

8.6.2.2 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 (Figure 104). Like adult 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 (young of the year) are present in the Bay-Delta region as they migrate to the ocean in the spring. Yearling spring-run Chinook salmon are expected to enter the Delta in late fall and early winter (late October through January). Juvenile spring-run Chinook salmon are expected to be present in the northern Delta region from December through May with a peak presence in March and April (Barnard et al. 2015; Miller et al. 2017; Speegle et al. 2013; U.S. Fish and Wildlife Service 2019; University of Washington Columbia Basin Research 2019; Figure 104; Figure 105.).

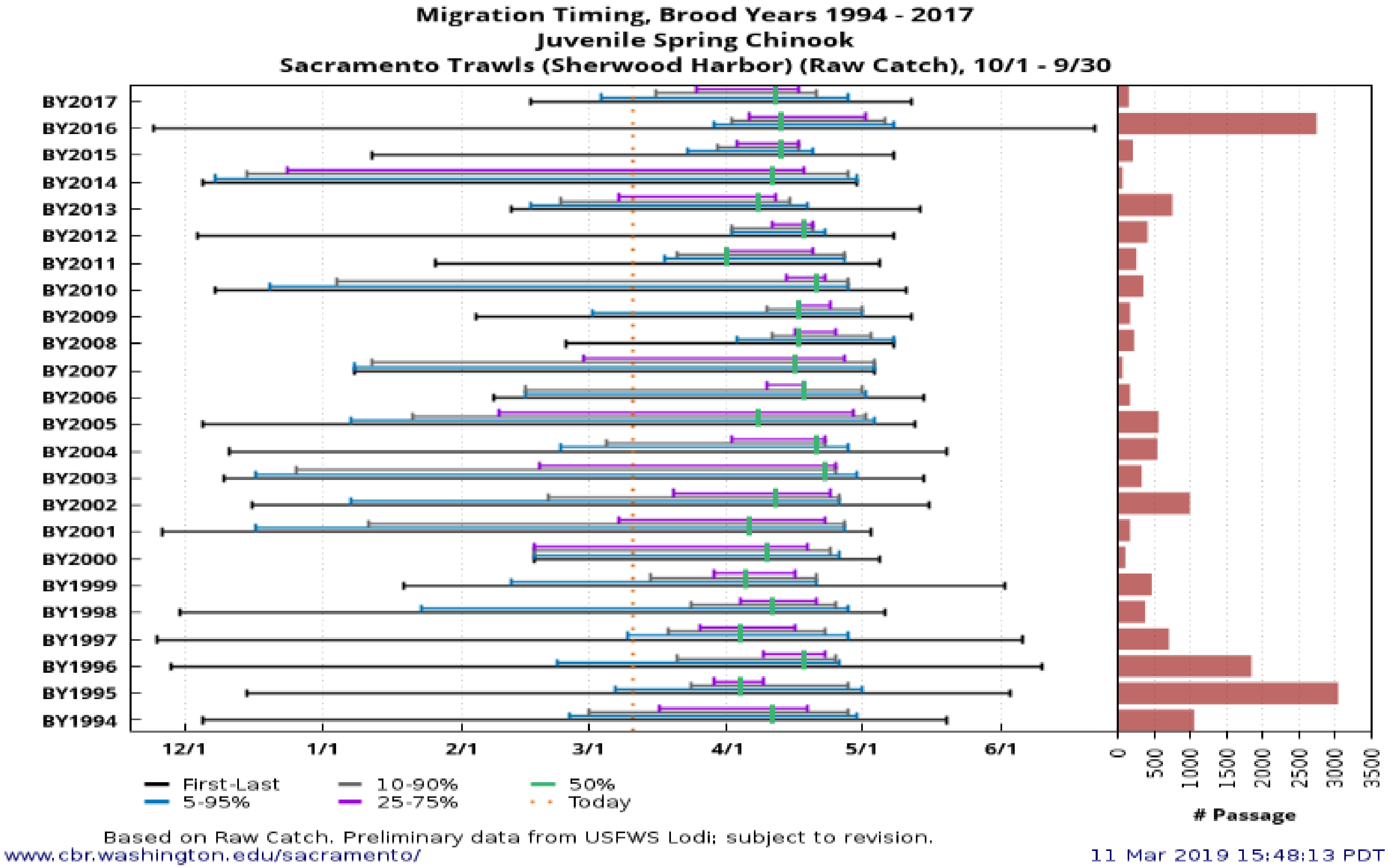


Figure 104. Juvenile Central Valley spring-run Chinook salmon migration timing past the Sherwood Harbor – Sacramento Trawl location for brood years 1994 to 2017.

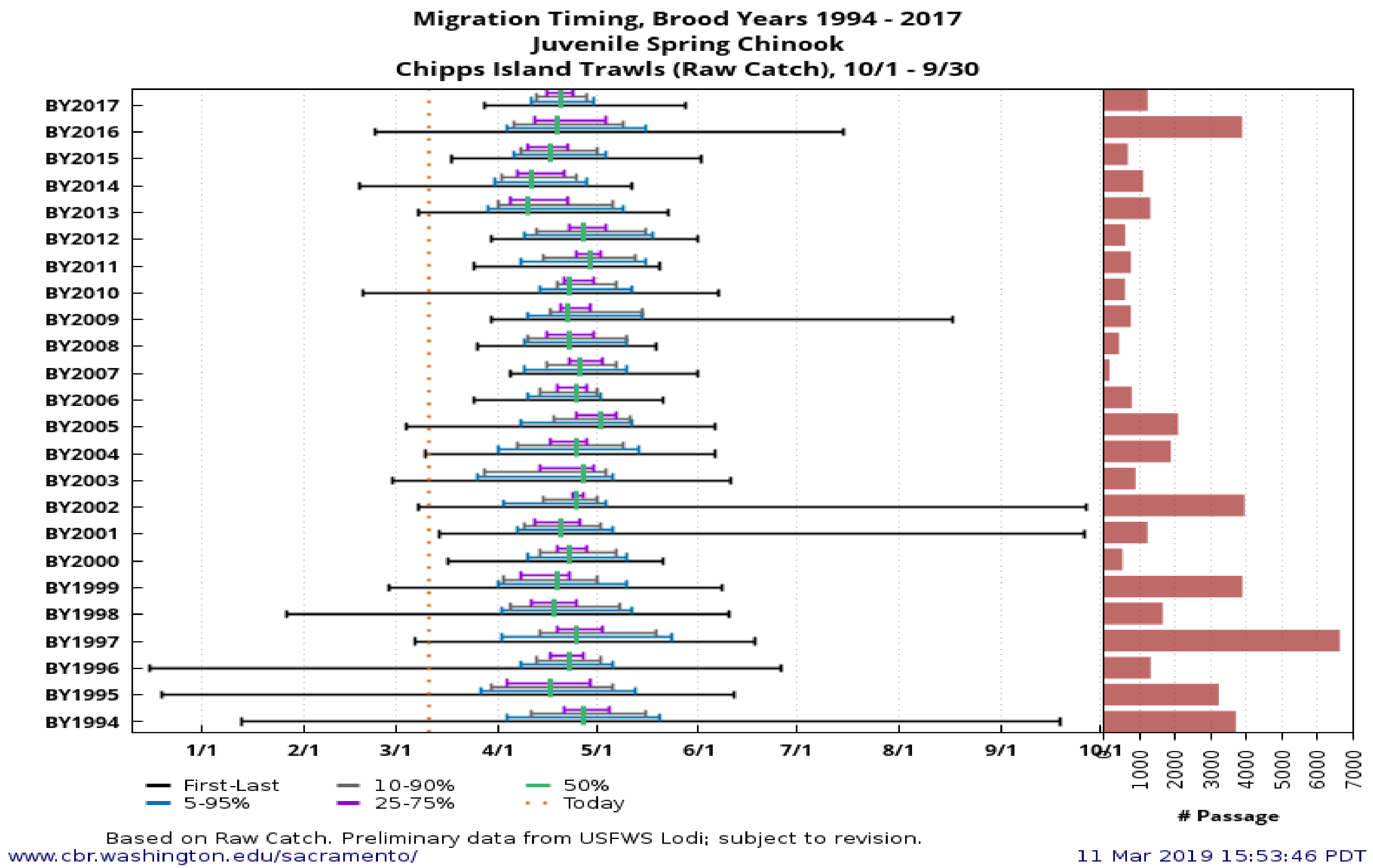


Figure 105. Juvenile Central Valley spring-run Chinook salmon migration timing past the Chipps Island Trawl location for brood years 1994 to 2017.

Currently there are no documented non-experimental populations of CV spring-run Chinook salmon in the San Joaquin River basin that would likely occur in the Bay-Delta region. However, there is evidence of Chinook salmon occurring in the Stanislaus and Tuolumne rivers that may represent residual populations of spring-run Chinook salmon or individuals that have strayed from other river basins and use the Stanislaus and Tuolumne rivers for spawning based on their run timing and the presence of fry and juveniles that show traits characteristic of spring-run populations such as hatching dates and seasonal sizes (Franks 2013; National Marine Fisheries Service 2016a). Furthermore, the San Joaquin River Restoration Program goal of re-establishing an experimental population of CV spring-run Chinook salmon in the San Joaquin River basin will create the potential that CV spring-run Chinook salmon will be present in the southern Delta and San Joaquin River regions of the Bay-Delta area over the lifetime of the proposed action. Note that in the CV spring-run Chinook Integration and Synthesis Section (Section 2.8.3), NMFS discusses the San Joaquin experimental population and associated 4(d) rule with respect to findings under this Biological Opinion.

There are no spawning areas in the Bay-Delta region that could be used by adult 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 spring-run Chinook salmon are reaching the size that smoltification occurs, and the majority of smolts would be moving downriver to enter the Delta on their emigration to the ocean. Spring-run Chinook salmon smolt outmigration 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 will remain in the tributaries through the summer and outmigrate the following fall and winter as yearlings.. 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 the San Joaquin River basin, adult migration is also likely to be strongly influenced by the flow levels in the San Joaquin River basin that provides access to the upstream holding and spawning areas. The broodstock for the spring-run Chinook salmon experimental population came from the Sacramento River basin (Feather River Fish Hatchery spring-run Chinook salmon) and are expected to exhibit similar migration timing behavior for both adult and juvenile life stages in the San Joaquin River basin.

8.6.2.3 California Central Valley Steelhead

The majority of CCV steelhead originate in the Sacramento River basin and its multiple tributaries and are comprised 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 Calaveras River and San Joaquin River basin 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.

Natural CCV steelhead juveniles (smolts) can 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 (Barnard et al. 2015; Miller et al. 2017; Speegle et al. 2013; University of Washington Columbia Basin Research 2019; Figure 106; Figure 107) and CVP and SWP fish salvage facilities (California Department of Fish and Wildlife 2018a). Adult steelhead begin to migrate through the northern portion of the Bay-Delta region (lower Sacramento River) starting 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"). The majority of adult 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 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 through January period, based on Stanislaus River fish weir counts. Adult CCV steelhead will 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.

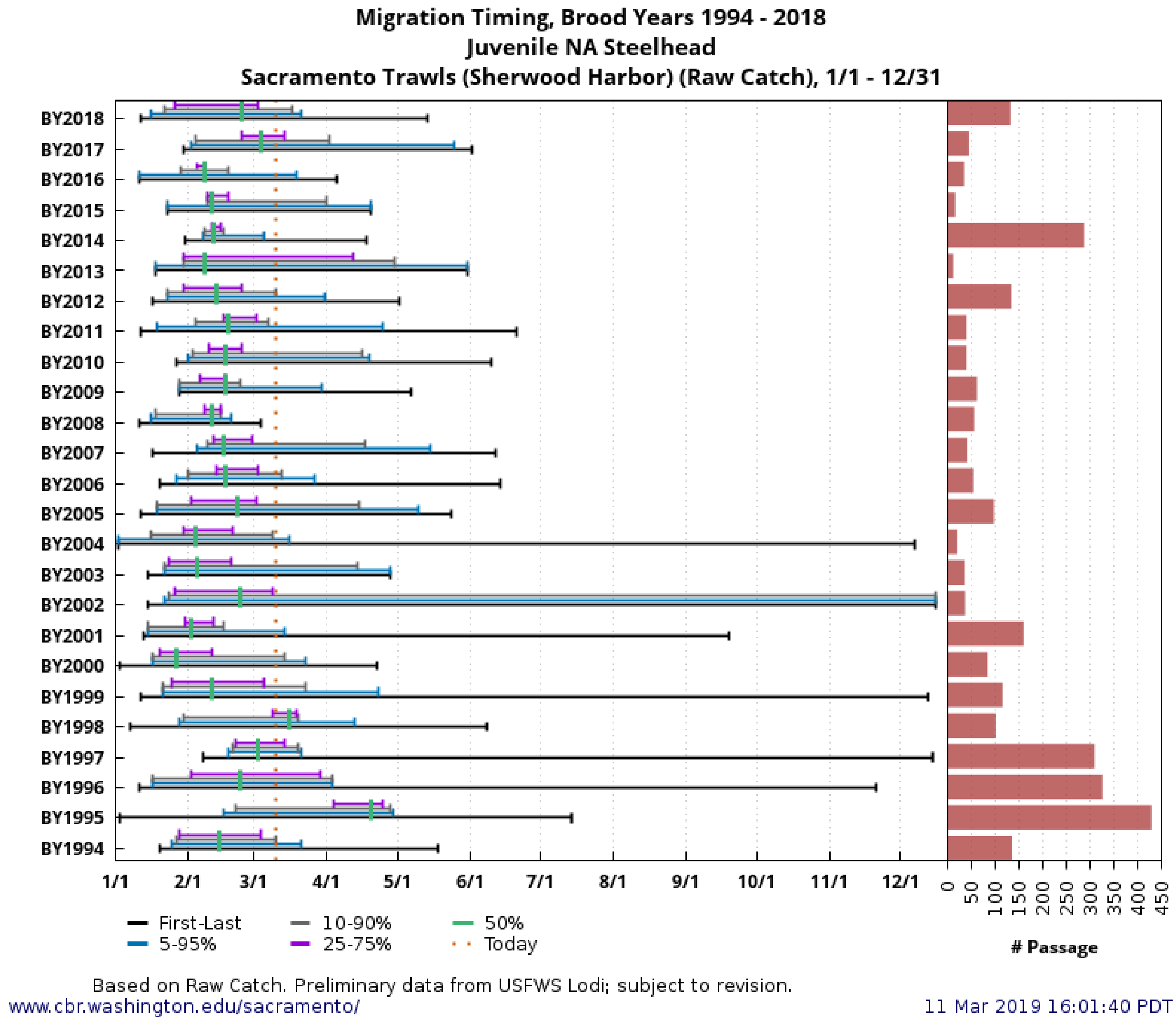


Figure 106. **Juvenile unclipped California Central Valley steelhead migration timing past the Sherwood Harbor – Sacramento Trawl location for brood years 1994 to 2017.**

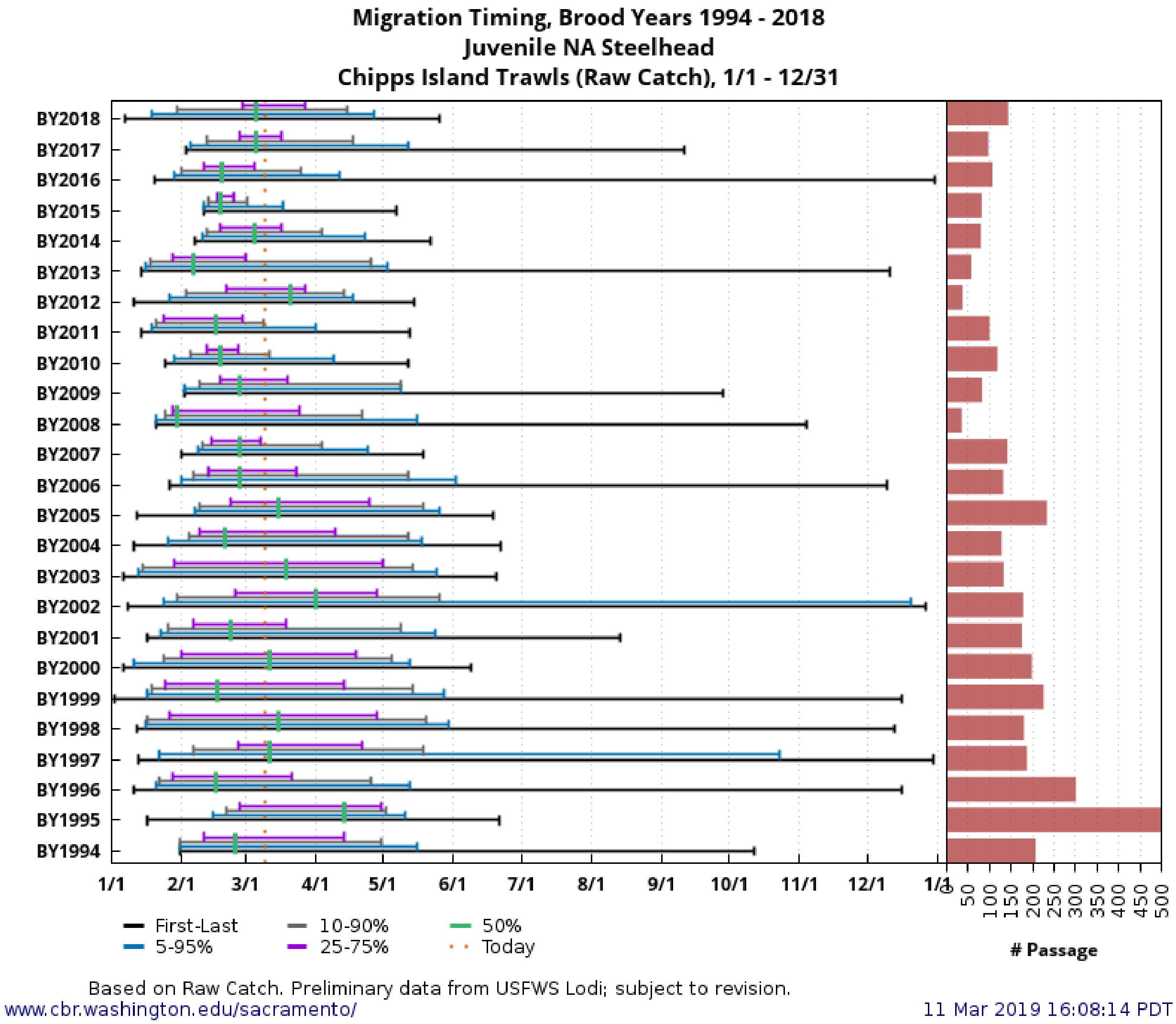


Figure 107. Juvenile unclipped California Central Valley steelhead migration timing past the Chipps Island Trawl location for brood years 1994 to 2017.

In the Sacramento River, juvenile CCV steelhead generally migrate to the ocean from early winter to early summer at one to three years of age and 100 to 250 mm 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/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/SWP fish salvage facilities. Juvenile 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 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.

8.6.2.4 Southern Distinct Population Segment of Green Sturgeon

Adult green sturgeon begin to enter the Bay-Delta in late February and early March during the initiation of their upstream spawning run (Heublein et al. 2009; Moyle et al. 1995). The peak of adult entrance into the Delta appears to occur in late February through early April, with fish arriving upstream of the Glen-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 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. The majority of post-spawn adult green sturgeon will move down river 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. Data on green sturgeon distribution are extremely limited and out-migration appears to be variable occurring at different times of year. Eleven years of recreational fishing catch data for adult green sturgeon (California Department of Fish and Game 2008; California Department of Fish and Game 2009; California Department of Fish and Game 2010a; California Department of Fish and Game 2011; California Department of Fish and Game 2012; California Department of Fish and Wildlife 2013a; California Department of Fish and Wildlife 2014a; California Department of Fish and Wildlife 2015a; California Department of Fish and Wildlife 2016a; California Department of Fish and Wildlife 2017a; DuBois and Danos 2018) show that they are present in the Delta during all months of the year (Figure 108). Although the majority of green sturgeon are expected to be found along the Sacramento River corridor and within the western Delta, observations of 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.

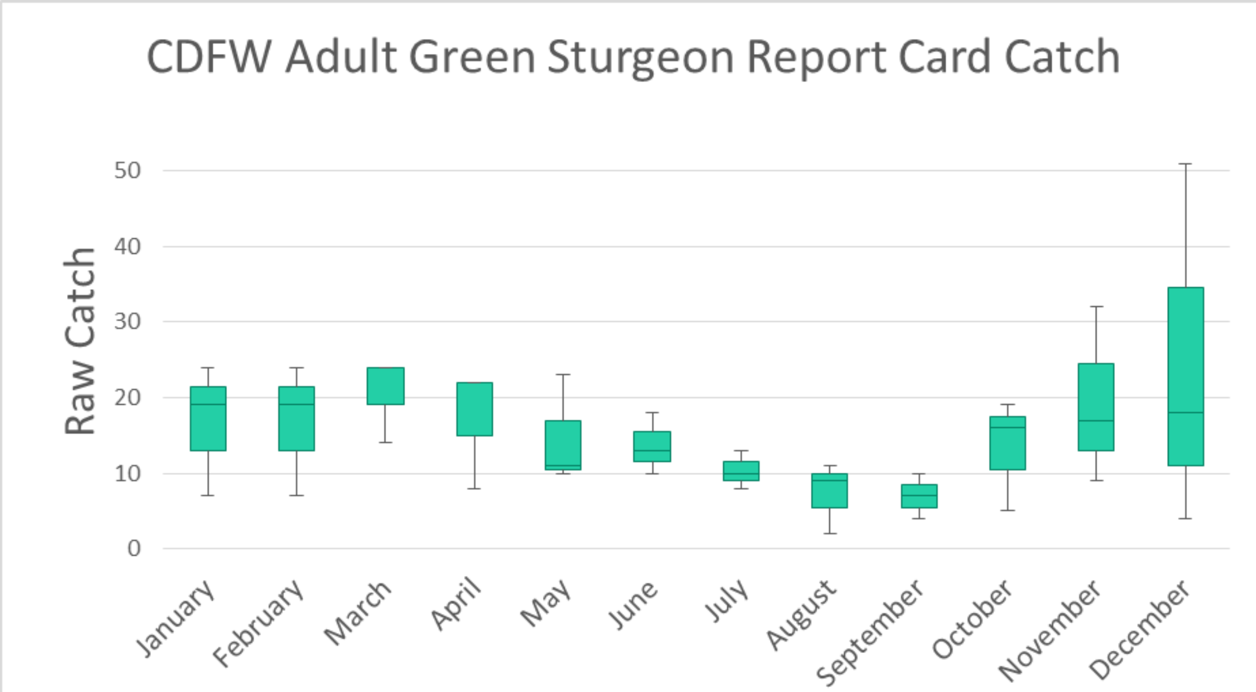


Figure 108. Adult raw catch data for sDPS green sturgeon in the Delta from 2007 to 2014.

Juvenile 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 green sturgeon at the seine and trawl monitoring sites. From 1981 to 2012, 7,200 juvenile green sturgeon were reported at the CVP/SWP fish salvage facilities (), which indicates a higher presence of juvenile green sturgeon during the spring and summer months in the south Delta where the export facilities are located.

Based on the above information, adult and juvenile sDPS green sturgeon were determined to be present in the Delta year-round.

8.6.3 Delta Cross Channel Operations

Operation of the Delta Cross Channel Gate is expected to influence downstream migration by providing false migration cues for juvenile and adult salmon, steelhead, and sturgeon to move from lower Sacramento River to the central Delta rather than their intended destination of the western Delta and San Francisco Bay.

The Delta Cross Channel gates are located in Walnut Grove, California and are a part of Reclamation's Central Valley Project, Delta Division. The Delta Cross Channel is operated by the San Luis and Delta Mendota Water Authority. The Delta Cross Channel is a controlled diversion channel on the left (eastern) bank of the Sacramento River approximately 30 miles downstream of the city of Sacramento. The Delta Cross Channel was constructed by Reclamation in 1951 to redirect high quality Sacramento River water southwards through Snodgrass Slough into the channels of the Mokelumne River system for a distance of 15 miles until it meets the San Joaquin River, and then another 35 miles through Old and Middle rivers to the CVP and SWP export facilities near Tracy.

The manmade channel of the Delta Cross Channel is 6,000 feet long and has a bottom width of approximately 210 feet, with side slopes of 3:1 giving a total width of 350 feet. The water depth of the channel is 26 feet deep with a nominal capacity of 3,500 cfs under normal conditions, but can divert up to 6,000 cfs if needed (Low and White 2004; Low and White 2006). Flow into the channel is controlled by two radial gates, each 60 feet wide by 30 feet tall, weighing a total of 243 tons. The gates extend 245 feet across the channel, creating a slight constriction of the channel.

The two gates are normally operated together. During high flows on the Sacramento River (greater than 20,000 to 25,000 cfs), the Delta Cross Channel gates are closed to prevent downstream flooding in the Snodgrass Slough and Mokelumne River systems. In addition, flows of this magnitude create scouring conditions at the Delta Cross Channel gate location and downstream of the facility, creating the potential for undercutting of the gate structure.

8.6.3.1 Deconstruct the Action - Proposed Operations of Delta Cross Channel Gates

Currently, Reclamation operates the Delta Cross Channel in the open position to (1) improve the transfer of water from the Sacramento River to the export facilities at the Banks and Jones Pumping Plants, (2) improve water quality in the southern Delta, and (3) reduce saltwater intrusion rates in the lower San Joaquin River in the western Delta. During the late fall, winter, and spring, the gates are often periodically closed to protect out-migrating salmonids from entering the interior Delta per the criteria in D-1641 and the NMFS 2009 BiOp (National Marine Fisheries Service 2009b) and to facilitate meeting the D-1641 Rio Vista flow objectives for fish passage.

The conditions for closing the Delta Cross Channel gates to protect fishery resources were first instituted in the State Water Resource Control Board D-1485 decision in 1978. In 1995, the Water Quality Control Plan (WQCP) for the Bay Delta (95-1) instituted additional operations of the Delta Cross Channel for fisheries protection (State Water Resources Control Board 1995). These criteria were reaffirmed in the State Water Resource Control Board’s D-1641 (State Water Resources Control Board 1999). Under the D-1641 criteria, the Delta Cross Channel gates may be closed for up to 45 days between November 1 and January 31 for fishery protection purposes. From February 1 through May 20, the gates are to remain closed for the protection of migrating fish in the Sacramento River. From May 21 through June 15, the gates may be closed for up to 14 days for fishery protection purposes. Reclamation determines the timing and duration of the closures after discussion with FWS, CDFW, and NMFS. These discussions occurred through the water operations management team as part of the weekly review of CVP/SWP operations. The water operations management team used input from the Salmon Decision Process to make its gate closure recommendations to Reclamation.

Reclamation’s proposed action is to operate the Delta Cross Channel gates to reduce juvenile salmonid entrainment risk consistent with Delta water quality requirements in D-1641 (U.S. Bureau of Reclamation 2019c) and beyond actions described in D-1641. From October 1 to November 30, if the Knights Landing catch index or Sacramento catch index are greater than three fish per day, Reclamation proposes to operate in accordance with Table 53 and Table 54 to determine whether to close the Delta Cross Channel gates and for how long.

Table 53. Delta Cross Channel October 1 through November 30 proposed action components.

Action Triggers	Action Responses
Water quality criteria per D-1641 are met and either the Knights Landing Catch Index or Sacramento Catch Index is greater than five fish per day	Within 48 hours, close the Delta Cross Channel gates and keep closed until the catch index is less than three fish per day at both the Knights Landing and Sacramento monitoring sites
Water quality criteria per D-1641 are met, either Knights Landing Catch Index or the Sacramento Catch Index are greater than three fish per day but less than or equal to five fish per day	Within 48 hours of trigger, Delta Cross Channel gates are closed. Gates will remain closed for 3 days
Water quality criteria per D-1641 are met, real-time hydrodynamic and salinity modeling shows water quality concern level targets are not exceeded during 28-day period following Delta Cross Channel closure and there is no observed deterioration of interior Delta water quality	Within 48 hours of start of Lower Mokelumne River attraction flow release, close the Delta Cross Channel gates for up to 5 days (dependent upon continuity of favorable water quality conditions)
Water quality criteria per D-1641 are met, real time hydrodynamic and salinity modeling shows water quality concern level targets are exceeded during 14-day period following Delta Cross Channel closure	No closure of Delta Cross Channel gates
The Knights Landing catch index or Sacramento catch index triggers are met but water quality criteria are not met per D-1641 criteria	Monitoring groups review monitoring data and provide to Reclamation. Reclamation and DWR determine what to do with a risk assessment

Table 54. Water quality level targets proposed for the opening of the Delta Cross Channel Gates.

Location	Electrical Conductivity [1]
Jersey Point	1800 umhos/cm
Bethel Island	1000 umhos/cm
Holland Cut	800 umhos/cm
Bacon Island	700 umhos/cm

[1] *Water Quality Model simulated 14-day average Electrical Conductivity*

The Knights Landing catch index and the Sacramento catch index are computed from the daily catch per unit information from the Knights Landing rotary screw trap monitoring program, the Sacramento regional beach seines, and the Sacramento River trawl monitoring efforts and adjusted for a standardized 24 hours of effort (one day of monitoring effort). From December 1 to January 31, the Delta Cross Channel gates will be closed. If drought conditions are observed (i.e. fall inflow conditions are less than 90 percent of historic flows) Reclamation and DWR will consider opening the Delta Cross Channel gates for up to five days for up to two events within this period to avoid D-1641 water quality exceedances. Reclamation and DWR will coordinate with FWS, NMFS and the State Water Resource Control Board on how to balance D-1641 water quality and ESA-listed fish requirements. Reclamation and DWR will conduct a risk assessment that will consider the Knights Landing rotary screw trap, Delta juvenile fish monitoring program (Sacramento trawl, beach seines), Rio Vista flow standards, 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 if fish responses may be altered by Delta Cross Channel operations. If the risk assessment determines that survival, route entrainment, or behavior change to create a new adverse effect not considered under this proposed action, Reclamation will not open the Delta Cross Channel. During a Delta Cross Channel gates opening between December 1 and January 31, the CVP and SWP will divert at Health and Safety pumping levels.

The primary avenues for juvenile salmonids emigrating downstream in the Sacramento River to enter the interior Delta, and hence becoming vulnerable to entrainment by the export facilities, is by diversion into the Delta Cross Channel and Georgiana Slough. Therefore, the operation of the Delta Cross Channel gates may significantly affect the survival of juvenile salmonids emigrating from the Sacramento River basin towards the ocean. Survival in the Delta interior is substantially lower than the mainstem Sacramento River (Perry et al. 2012; Perry et al. 2010; Romine et al. 2013).

NMFS made the following assumptions regarding the proposed operations for the analysis of effects, informed by the conversations during the consultation meeting on May 21, 2019, and analyzed effects accordingly:

- Frequency of Delta Cross Channel gate operations (opening gates) for water quality concerns during the fall and early winter remain similar to past water years;
- The Fish Monitoring Working Group, which is a new creation of the proposed action, will function in a similar manner to the currently existing Delta operations for salmonids and sturgeon working group and will meet at least once a week to provide near real-time analysis of fish monitoring data from the Central Valley to Reclamation;
- Monitoring of older juvenile Chinook salmon (by length-at-date) catch will be the basis of the Knights Landing catch index and Sacramento catch index threshold triggers for closing the Delta Cross Channel gates;
- The Delta Cross Channel gates may be opened for up to five days for up to two water quality concern events from December 1 to January 31 when drought conditions are observed and gate opening will help to address water quality concerns; this operation is assumed to occur 1 in 10 years or less.

8.6.3.2 Assess Species Exposure to Proposed Delta Cross Channel Operations

For the purposes of this analysis, “exposure” is defined as the temporal and spatial co-occurrence of the life stages of listed species (winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon) and the stressors associated with the proposed action.

A few steps are involved in assessing listed species exposure. First, the life stages and associated timings of listed species are identified. The second step is to identify the spatial distribution of each life stage. The last step is to overlay the temporal and spatial distributions of proposed action-related stressors on top of the temporal and spatial distributions of the listed species with the location of the Delta Cross Channel gates and the effects of the stressors associated with its operations.

There are four general periods for operations of the Delta Cross Channel gates under Reclamation's proposed procedures which differ slightly from those contained in the D-1641 operational criteria. From October 1 through November 30, the gates are operated per the actions described in Table 53 This period is different than the operations described in the D-1641 criteria. In general, Reclamation proposes for the Delta Cross Channel gates to remain open unless a trigger threshold is met by the observed catch indices at the Knights Landing rotary screw trap monitoring location or from either of the monitoring efforts that comprise the Sacramento catch index (Sacramento regional beach seines or the Sacramento trawl located near Sherwood Harbor on the Sacramento River). From December 1 through January 31, the Delta Cross Channel gates are proposed to be closed, unless drought conditions are observed and Reclamation determines that it can avoid D-1641 water quality exceedances by opening the Delta Cross Channel gates for up to five days for up to two events within this period. As noted earlier, this operation is assumed to occur in less than one in ten years.

Under the current operating scenario, which includes actions required by the NMFS 2009 BiOp, the Delta Cross Channel gates are to be closed from December 1 through December 14 if the water quality criteria identified in D-1641 are met, with an exception for NMFS-approved experiments. If the water quality criteria identified in D-1641 were not met, and the Knights Landing Catch Index (Knights Landing catch index) or Sacramento Catch Index (Sacramento catch index) are less than three fish per day, the gates could be opened until the water quality criteria are met, then closed within 24 hours of compliance. If the Knights Landing catch index or Sacramento catch index were greater than three fish per day, then the Delta operations for salmonids and sturgeon working group would review the monitoring data and make recommendations to NMFS and water operations management team for gate operations. From December 15 through January 31, the gates are closed except for permitted experiments (maximum of 5 days of gates in the open position) with NMFS approval for ESA compliance. Current operating scenario procedures also permitted a one-time gate opening between December 15 and January 5 for up to three days, upon NMFS concurrence, when necessary to maintain Delta water quality in response to the astronomical high tide, coupled with low inflow conditions. The Delta Cross Channel gates were to be operated such that the gates were opened one hour after sunrise to one hour prior to sunset, then return to full closure. During this period of gate openings, Reclamation and DWR were required to reduce exports down to the minimum health and safety level (1,500 cfs combined exports).

Under the proposed operations scenario, the Delta Cross Channel gates may potentially be opened more frequently (twice) after December 15 (during drought conditions only) and for a longer period of time (up to five days each) than allowed under current operating scenario conditions. In addition, the opening of the gates may be determined by reaching a water quality "concern level" based on modeling outputs, rather than an actual exceedance of the water quality criteria required in D-1641. However, Delta Cross Channel opening will only occur when drought conditions are observed (defined as "fall inflow conditions are less than 90 percent of historic flows" and clarified in the June 14, 2019 proposed action; (U.S. Bureau of Reclamation 2019b)) and modeling shows that Delta Cross Channel opening will avoid exceedance of a water quality concern level. This joint condition is expected to occur in less than one in ten years, and Reclamation and DWR will coordinate with FWS, NMFS and the State Water Resource Control Board on how to balance D-1641 water quality and ESA-listed fish requirements.

From February 1 through May 20, the gates are proposed to remain closed to protect listed fish. This action parallels the actions required by D-1641. From May 21 to June 15, the gates will be closed for 14 days to provide protection for listed fish consistent with D-1641 criteria. From June 16 through September 30, the gates are proposed to remain open, unless water quality criteria for Delta outflows or electrical conductivity exceedances in the lower Sacramento River require the gates to close to alleviate these water quality concerns.

8.6.3.2.1 Sacramento River winter-run Chinook salmon

The timing of observations of natural (i.e., non-clipped fish) juvenile 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 (Table 55). For the period of October 1 to November 30, few natural juvenile winter-run Chinook salmon are observed in the catch of the Sacramento Trawl. On average, the date of the first observation of natural juvenile winter-run Chinook salmon for the period covering brood years 1994 to 2017 is December 5, the median date of the first observation of natural winter-run Chinook salmon in the trawl for this period of time is November 25. The earliest date of the first appearance of natural winter-run Chinook salmon in the Sacramento trawl is September 10 (1998 – a wet year) and the latest date for the first appearance of a natural juvenile winter-run Chinook salmon is March 3 (2016 – a drought year). From December 1 through January 31, approximately 50 percent of the natural juvenile 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 February 1, with the median date of February 13, for the period of 1994 to 2017.

Table 55. Timing of juvenile winter-run Chinook salmon passage past Sherwood Harbor (Sacramento Trawl) for brood years 1994 to 2017.

Brood Year	First Passage Date	5% Passage Date	10% Passage Date	25% Passage Date	50% Passage Date	75% Passage Date	90% Passage Date	95% Passage Date	Last Passage Date
Average	**5-Dec**	**17-Dec**	**24-Dec**	**9-Jan**	**1-Feb**	**20-Feb**	**12-Mar**	**17-Mar**	**31-Mar**
Median	**25-Nov**	**11-Dec**	**15-Dec**	**29-Dec**	**13-Feb**	**4-Mar**	**19-Mar**	**25-Mar**	**9-Apr**
2017	1/13/18	1/13/18	1/15/18	2/11/18	3/15/18	3/18/18	3/24/18	3/24/18	3/25/18
2016	3/3/17	3/13/17	3/16/17	3/22/17	3/30/17	4/4/17	4/8/17	4/10/17	4/21/17
2015	11/6/15	11/6/15	12/24/15	12/24/15	3/16/16	3/25/16	4/1/16	4/22/16	4/22/16
2014	11/5/14	11/5/14	11/28/14	12/8/14	12/8/14	12/22/14	3/20/15	4/6/15	4/17/15
2013	2/9/14	2/12/14	2/12/14	2/13/14	2/15/14	3/5/14	3/10/14	3/14/14	4/4/14
2012	11/23/12	11/23/12	11/23/12	11/26/12	11/26/12	12/3/12	12/3/12	12/3/12	12/7/12
2011	1/25/12	1/27/12	2/1/12	3/16/12	3/19/12	3/30/12	3/30/12	3/30/12	4/13/12
2010	10/29/10	10/29/10	10/29/10	12/13/10	2/22/11	3/18/11	4/13/11	4/13/11	4/15/11
2009	10/23/09	10/23/09	10/23/09	11/6/09	2/5/10	2/17/10	2/26/10	2/26/10	2/26/10
2008	12/22/08	12/22/08	1/28/09	2/17/09	2/18/09	2/18/09	2/27/09	2/27/09	2/27/09
2007	1/7/08	1/7/08	1/7/08	1/9/08	1/28/08	2/6/08	2/27/08	2/27/08	3/3/08
2006	11/20/06	12/11/06	12/15/06	12/18/06	2/12/07	2/12/07	2/16/07	2/28/07	2/28/07
2005	11/2/05	11/14/05	11/14/05	12/5/05	12/23/05	3/8/06	3/20/06	3/29/06	4/24/06
2004	11/1/04	11/10/04	12/10/04	12/13/04	1/3/05	2/22/05	2/25/05	3/4/05	4/4/05
2003	12/6/03	12/10/03	12/10/03	12/10/03	12/10/03	1/5/04	2/18/04	3/12/04	3/22/04
2002	11/8/02	12/16/02	12/16/02	12/16/02	1/15/03	3/3/03	3/19/03	3/26/03	4/28/03
2001	9/10/01	11/19/01	11/23/01	11/26/01	11/30/01	12/21/01	2/23/02	2/23/02	4/5/02
2000	1/15/01	1/26/01	1/31/01	2/16/01	2/23/01	2/23/01	3/12/01	3/19/01	4/13/01
1999	1/18/00	1/18/00	1/20/00	1/31/00	2/11/00	3/22/00	3/22/00	3/27/00	3/29/00
1998	10/19/98	11/23/98	11/23/98	11/24/98	11/27/98	12/7/98	3/18/99	3/19/99	4/15/99
1997	11/24/97	11/26/97	11/29/97	2/23/98	3/17/98	3/19/98	3/23/98	4/3/98	4/17/98
1996	11/25/96	12/11/96	12/12/96	2/18/97	2/27/97	3/18/97	3/26/97	3/27/97	4/22/97
1995	12/15/95	12/16/95	12/16/95	1/2/96	3/1/96	3/19/96	3/26/96	3/27/96	4/2/96
1994	12/27/94	2/21/95	2/24/95	2/27/95	3/7/95	4/7/95	4/13/95	4/14/95	4/27/95

Source: SacPas. Available at: http://www.cbr.washington.edu/sacramento/tmp/hrt_1552451186_673.html

During the period of February 1 to May 20, when the gates are closed, the remainder of the natural juvenile winter-run Chinook salmon cohort has passed through the Sherwood Harbor location. The average last date of the observation of natural juvenile winter-run Chinook salmon in the trawl is March 31, with the median date of the last observation being slightly later on April 9. Typically, no observation of natural juvenile 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 winter-run Chinook salmon from the Livingston Stone National Fish Hatchery 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 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 catch of winter-run Chinook salmon at the Knights Landing rotary screw trap monitoring location (del Rosario et al. 2013; Figure 109). In Figure 109, the first day that flows reached 400 m3 s-1 (solid vertical line) is nearly coincident with the day of catch spike (increase of five percent of cumulative catch; dotted line) and the day of median catch (50th percentile of cumulative catch; dashed line; years refer to spring emigration season).

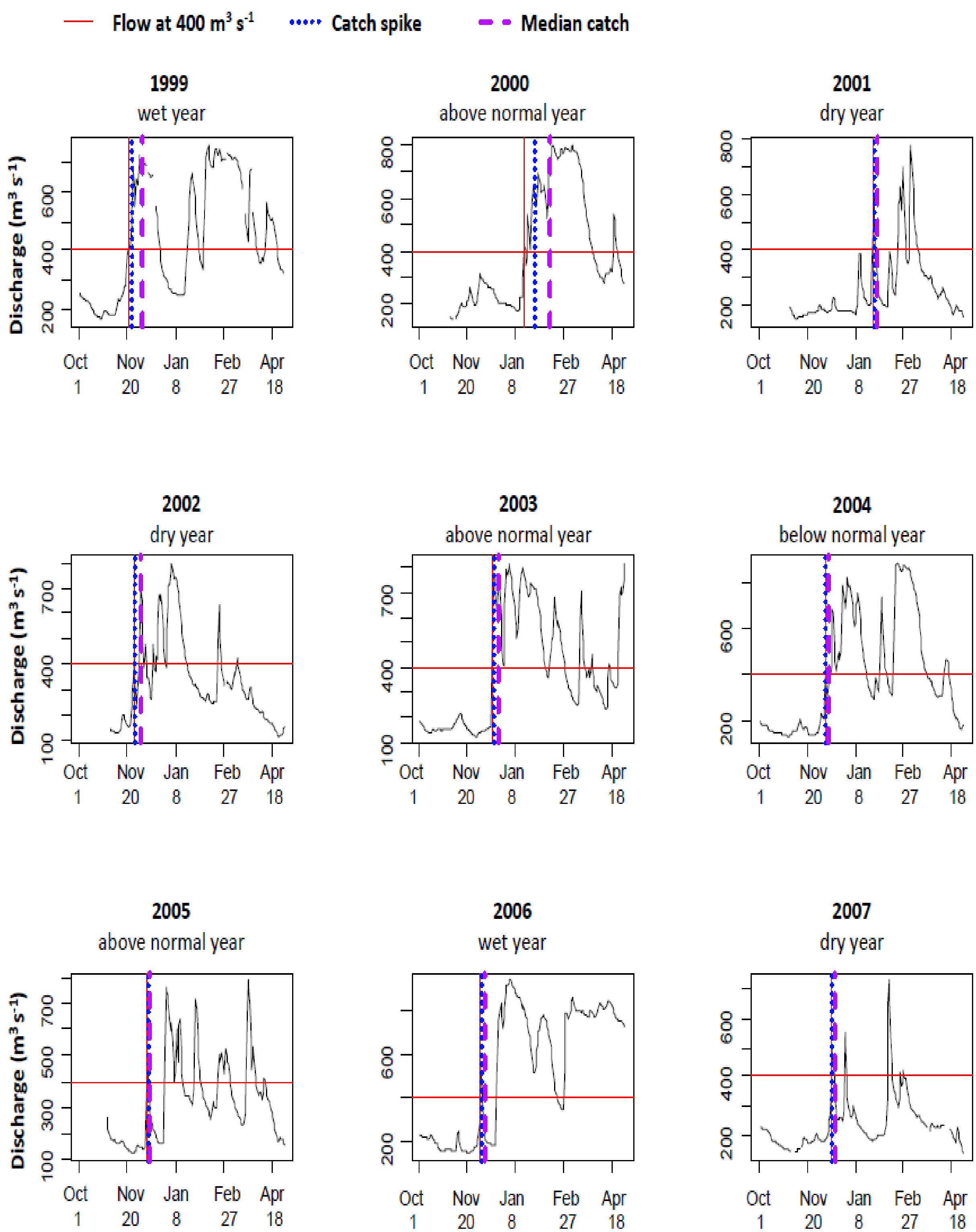


Figure 109. Flow threshold of 400 cubic meters per second triggers abrupt and substantial winter-run migration into the Delta at Knights Landing.

Source: Figure 5 of del Rosario et al. (2013)

Most adult 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 main stem 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 main stem Sacramento River downstream of the Delta Cross Channel gate location. During the period from November through January, when adult 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 (winter-run and yearling 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 main stem Sacramento River will flow into the Mokelumne River system and potentially attract adult winter-run Chinook salmon into the system from the San Joaquin River main stem. 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 winter-run Chinook salmon migration (June), the gates may be either closed or open. This may encourage straying in any late migrating adult winter-run Chinook salmon encountering the open gate condition.

8.6.3.2.2 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 (Table 56). 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 spring-run Chinook salmon for the period covering brood years 1994 to 2017 is December 29, the median date of the first observation of CV spring-run Chinook salmon in the trawl for this period of time is December 13. 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 which was 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 16 (2000 which was an above normal year).

Table 56. Timing of juvenile Central Valley spring-run Chinook salmon passage past Sherwood Harbor (Sacramento Trawl) for brood years 1994 to 2017.

Brood Year	First Passage Date	5% Passage Date	10% Passage Date	25% Passage Date	50% Passage Date	75% Passage Date	90% Passage Date	95% Passage Date	Last Passage Date
Average	**29-Dec**	**10-Feb**	**25-Feb**	**19-Mar**	**11-Apr**	**19-Apr**	**25-Apr**	**27-Apr**	**15-May**
Median	**13-Dec**	**18-Feb**	**9-Mar**	**28-Mar**	**11-Apr**	**19-Apr**	**25-Apr**	**27-Apr**	**11-May**
2017	2/15/18	3/3/18	3/15/18	3/24/18	4/11/18	4/16/18	4/20/18	4/27/18	5/11/18
2016	11/23/16	3/28/17	4/1/17	4/5/17	4/12/17	5/1/17	5/5/17	5/7/17	6/21/17
2015	1/11/16	3/21/16	3/28/16	4/1/16	4/11/16	4/15/16	4/15/16	4/18/16	5/6/16
2014	12/5/14	12/8/14	12/15/14	12/24/14	4/10/15	4/17/15	4/27/15	4/29/15	4/29/15
2013	2/11/14	2/15/14	2/22/14	3/7/14	4/7/14	4/11/14	4/14/14	4/18/14	5/13/14
2012	12/3/12	4/1/13	4/1/13	4/10/13	4/17/13	4/19/13	4/19/13	4/22/13	5/7/13
2011	1/25/12	3/16/12	3/19/12	3/30/12	3/30/12	4/18/12	4/25/12	4/25/12	5/3/12
2010	12/8/10	12/20/10	1/3/11	4/13/11	4/20/11	4/22/11	4/27/11	4/27/11	5/10/11
2009	2/3/10	3/1/10	4/9/10	4/16/10	4/16/10	4/23/10	4/30/10	4/30/10	5/11/10
2008	2/23/09	4/2/09	4/10/09	4/15/09	4/16/09	4/24/09	5/2/09	5/7/09	5/7/09
2007	1/7/08	1/7/08	1/11/08	2/27/08	4/14/08	4/25/08	5/2/08	5/2/08	5/2/08
2006	2/7/07	2/14/07	2/14/07	4/9/07	4/17/07	4/17/07	4/30/07	5/1/07	5/14/07
2005	12/5/05	1/6/06	1/20/06	2/8/06	4/7/06	4/28/06	5/1/06	5/3/06	5/12/06
2004	12/10/04	2/22/05	3/4/05	4/1/05	4/20/05	4/22/05	4/22/05	4/27/05	5/19/05
2003	12/10/03	12/17/03	12/26/03	2/17/04	4/21/04	4/23/04	4/23/04	4/28/04	5/13/04
2002	12/16/02	1/6/03	2/19/03	3/19/03	4/11/03	4/23/03	4/25/03	4/25/03	5/15/03
2001	11/26/01	12/17/01	1/10/02	3/7/02	4/5/02	4/22/02	4/26/02	4/26/02	5/2/02
2000	2/16/01	2/16/01	2/16/01	2/16/01	4/9/01	4/18/01	4/23/01	4/25/01	5/4/01
1999	1/18/00	2/11/00	3/13/00	3/27/00	4/3/00	4/14/00	4/19/00	4/19/00	5/31/00
1998	11/30/1998	1/22/1999	3/23/1999	4/3/1999	4/10/1999	4/20/99	4/24/99	4/27/99	5/5/99
1997	11/25/97	3/9/98	3/18/98	3/25/98	4/3/98	4/15/98	4/22/98	4/27/98	6/5/98
1996	11/27/96	2/21/97	3/20/97	4/8/97	4/17/97	4/22/97	4/24/97	4/25/97	6/9/97
1995	12/15/95	3/5/96	3/22/96	3/27/96	4/2/96	4/7/96	4/26/96	4/29/96	6/1/96
1994	12/5/94	2/24/95	2/28/95	3/16/95	4/10/95	4/18/95	4/27/95	4/29/95	5/19/95

Source: SacPas. Available at: http://www.cbr.washington.edu/sacramento/tmp/hrt_1552495104_288.html

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 of 1994 to 2017. 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 27, 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 15, with the median date of the last observation being slightly earlier on May 11. Historically, very few natural young-of-the-year juvenile 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 spring-run Chinook salmon from the Feather River Fish Hatchery are typically released in the spring in March and April, and normally would encounter the Delta Cross Channel gates when they are closed. There is the potential that if fish were 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 over summering in rivers and stream 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 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 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 spring-run 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 anytime 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 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 (60-70 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 starting 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 winter-run Chinook salmon.

8.6.3.2.3 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 (Table 57). 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 1998 to 2017 is

January 16, the median date of the first observation of CCV steelhead in the trawl for this period of time is January 15. The earliest date of the first appearance of CCV steelhead in the Sacramento trawl is January 2 (2003 – an above normal year) and the latest date for the first appearance of a steelhead juvenile is January 31 (2013 – a dry year).

Table 57. Timing of juvenile California Central Valley steelhead passage past Sherwood Harbor (Sacramento Trawl) for brood years 1998 to 2017.

Brood Year	First Passage Date	5% Passage Date	10% Passage Date	25% Passage Date	50% Passage Date	75% Passage Date	90% Passage Date	95% Passage Date	Last Passage Date
Average	16-Jan	24-Jan	28-Jan	7-Feb	18-Feb	3-Mar	31-Mar	18-Apr	1-Jul
Median	15-Jan	22-Jan	28-Jan	5-Feb	16-Feb	2-Mar	20-Mar	3-Apr	2-Jun
2017	1/12/18	1/16/18	1/22/18	1/26/18	2/24/18	3/3/18	3/17/18	3/21/18	5/14/18
2016	1/30/17	2/2/17	2/4/17	2/24/17	3/4/17	3/14/17	4/2/17	5/25/17	6/2/17
2015	1/11/16	1/11/16	1/29/16	2/5/16	2/8/16	2/8/16	2/18/16	3/18/16	4/4/16
2014	1/23/15	1/23/15	2/9/15	2/9/15	2/11/15	2/18/15	4/1/15	4/20/15	4/20/15
2013	1/31/14	2/7/14	2/8/14	2/11/14	2/12/14	2/15/14	2/16/14	3/5/14	4/18/14
2012	1/18/13	1/18/13	1/30/13	1/30/13	2/8/13	4/12/13	4/30/13	5/31/13	5/31/13
2011	1/17/12	1/23/12	1/23/12	1/30/12	2/13/12	2/24/12	3/9/12	3/30/12	5/1/12
2010	1/12/11	1/19/11	2/4/11	2/16/11	2/18/11	3/2/11	3/7/11	4/25/11	6/21/11
2009	1/27/10	2/1/10	2/3/10	2/10/10	2/17/10	2/24/10	4/16/10	4/19/10	6/10/10
2008	1/28/09	1/28/09	1/28/09	2/6/09	2/17/09	2/17/09	2/23/09	3/30/09	5/7/09
2007	1/11/08	1/16/08	1/18/08	2/8/08	2/11/08	2/15/08	2/15/08	2/19/08	3/3/08
2006	1/17/07	2/5/07	2/9/07	2/12/07	2/16/07	2/28/07	4/17/07	5/15/07	6/12/07
2005	1/20/06	1/27/06	2/1/06	2/13/06	2/17/06	3/3/06	3/13/06	3/27/06	6/14/06
2004	1/12/05	1/19/05	1/19/05	2/2/05	2/22/05	3/2/05	4/15/05	5/10/05	5/24/05
2003	1/2/04	1/2/04	1/16/04	1/30/04	2/4/04	2/20/04	3/8/04	3/15/04	12/6/04
2002	1/15/03	1/22/03	1/22/03	1/24/03	2/5/03	2/19/03	4/14/03	4/28/03	4/28/03
2001	1/15/02	1/22/02	1/24/02	1/26/02	2/23/02	3/9/02	12/16/02	12/16/02	12/16/02
2000	1/13/01	1/15/01	1/15/01	1/31/01	2/2/01	2/12/01	2/16/01	3/14/01	9/19/01
1999	1/3/00	1/17/00	1/17/00	1/20/00	1/27/00	2/11/00	3/13/00	3/22/00	4/21/00
1998	1/12/99	1/21/99	1/21/99	1/25/99	2/11/99	3/5/99	3/23/99	4/23/99	12/13/99

Source: SacPas. Available at: http://www.cbr.washington.edu/sacramento/tmp/hrt_1552496507_849.html

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 February 18, for the period of 1998 to 2017. The median date for 50 percent passage is February 16. During the period of February 1 to May 20, when the gates are closed, nearly all of the juvenile CCV steelhead population has passed through the Sherwood Harbor location. On average, by April 18, 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 July 1, with the median date of the last observation a month earlier on June 2. Historically, very few juvenile CCV steelhead 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 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 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 (60-70 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.

8.6.3.2.4 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 in the vicinity of 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 Salmon and Sturgeon Assessment of Indicators by Life Stage (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 outmigrating juvenile stage in the Upper and Middle Sacramento River and the Bay-Delta.

The threat posed to sDPS green sturgeon by altered water temperatures due to impoundments was ranked high in the Sacramento River Basin for eggs and juveniles. Impoundments alter flow regimes, which in turn affect the water temperature of the river downstream of the impoundment. If water released from the impoundments results in water temperatures that are not within the optimal thermal window for development, survival and growth will be limited.

8.6.3.3 Assess Response of Species 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. The Delta Cross Channel is a controlled diversion channel with two operable radial gates. When the gates are fully open, up to 6,000 cfs of water to pass down the Delta Cross Channel into the North and South Forks of the Mokelumne River in the central Delta (Low and White 2006). During the periods of winter-run Chinook salmon emigration when the Delta Cross Channel gates are proposed to be operational (*i.e.*, October to January) through the lower Sacramento River, approximately 40 percent of the Sacramento River flow (as measured at Freeport) can be diverted into the interior of the Delta through the Delta Cross Channel and Georgiana Slough when both gates are open. When the gates are closed, approximately 15 to 20 percent (as measured at Freeport) of the Sacramento River flow is diverted down the Georgiana Slough channel[11].

The operations of the gates affect the water flow surrounding the junction of the Delta Cross Channel with the main stem Sacramento River and 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, and
- creation of false attractant flows through the open Delta Cross Channel gates.

8.6.3.3.1 Routing

As acoustic-tagged Chinook salmon migrate downriver in the mainstem Sacramento River, fish have the opportunity to be diverted into alternative migratory routes. At the junctions of Sutter and Steamboat sloughs, approximately 30-40 percent of the migrating fish in the mainstem Sacramento River were detected moving into these routes, leaving approximately 60-70 percent of the migrating fish to move downstream towards the location of the Delta Cross Channel gates. When the Delta Cross Channel gates are open, juvenile fish moving within the main stem 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 channel (Newman and Brandes 2010; Perry et al. 2012; Perry et al. 2010; Romine et al.

[11] Instantaneous percentages can be much higher depending on the interaction of river flow and tidal flow as described in Horn and Blake (2004).

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 main stem 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 main stem 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 main stem 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.

8.6.3.3.2 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 main stem 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 travelled in the Delta and indicated that mortality rate per kilometer travelled actually increased as fish travelled 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 travelling through the main stem 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 steelhead emigration would be associated with lower river inflows from the Sacramento River and San Joaquin rivers, leading to the reduced water quality conditions that would necessitate the gate openings. Low water flow in the main stem 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 main stem Sacramento River due to a smaller volume of water remaining in that channel after passing the Delta Cross Channel junction with the open gates. The reduction in flow in the main stem 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.

8.6.3.3.3 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 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 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 bi-directional (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 main stem 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 operating 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 main stem 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 less 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.

8.6.3.3.4 Survival related to transit routes and predator exposure

Perry et al. (2010), Perry et al. (2012), 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 not only were the interior Delta routes longer, but they had higher mortality rate per unit distance travelled 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 is dependent on travel time through the reach and not necessarily the distance travelled. 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 travelled. This could increase the number of predator encounters relative to the length of the reach, therefore increasing mortality rates per a unit distance travelled.

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 present within a given reach. With each passage past the junction, the probability of routing into the alternate route increases. If that route leads into 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; California Department of Water Resources 2015; California Department of Water Resources 2016) as a requirement of the NMFS 2009 Opinion, RPA Action IV.1.3 (National Marine Fisheries Service 2009b). 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 mainstem of the Sacramento River and reducing the fraction that could enter the Georgiana Slough route.

8.6.3.3.5 Increased risk of entrainment at the CVP and SWP 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 main stem. Tidal forcing can redirect fish into the channels of Old and Middle rivers, where the influence of the exports is manifested as net reverse flows towards the export facilities.

8.6.3.3.6 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, steelhead, and 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 or San Joaquin rivers to spawn. These movements included "false" runs up the main stems 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 main stem Sacramento River to continue their upstream migration.

8.6.3.4 Risk to Sacramento River winter-run Chinook salmon

Juvenile 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 Table 55, 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 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 winter-run Chinook salmon population sampled at Knights Landing (del Rosario et al. 2013). If flows exceed approximately 20,000 to 25,000 cfs at Freeport, then the Delta Cross Channel gates are closed for flood protection in downstream river reaches. This would also be protective of 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 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 gates are opened (up to two times for 5 days each) for water quality concerns, then a substantial proportion of the juvenile 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 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 main stem 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 (Table 54). During dry years, juvenile winter-run Chinook salmon downstream migration is usually delayed until January or February, when winter storms first arrive. The delay in juvenile 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 of the juvenile 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 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 main stem Sacramento River should not be impeded, even though fish have strayed into the Mokelumne River system. After December and through the end of January, the Delta Cross Channel gates will typically be closed, and adult winter-run Chinook salmon are unlikely to be attracted into the Mokelumne River system due to the false attraction of Sacramento River water coming through the system in substantial amounts. 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 winter-run Chinook salmon being attracted into the Mokelumne River system by the additional flow of Sacramento River water through the gates, though this effect is expected in less than 1 in 10 years. When the gates are closed after 5 days, these fish then run the risk of being caught behind the closed gates and their upstream migration delayed 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.

8.6.3.5 Risk to Central Valley Spring-run Chinook Salmon

Natural yearling CV spring-run Chinook salmon are expected to enter the Delta in late fall and early winter (late October through January). Natural 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 five percent of a given juvenile CV spring-run Chinook salmon cohort has entered the Delta region near the Delta Cross Channel gates (Table 56), with the first demonstrable arrival of juveniles occurring in mid- to late-December. Based on the proposed operations of the Delta Cross Channel gates, up to five percent of the juvenile cohort will be exposed to the potential opening of the gates (December through January) in less than one in ten years, 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 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 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 these impacts are expected in less than 1 in 10 years. This should not impede migration. As previously explained for adult 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.

8.6.3.6 Risk to California Central Valley Steelhead

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 River trawl have occurred in most months. However, few fish are actually observed from May through the following fall. Starting in mid-January, observations of juvenile CCV steelhead begin to increase in the Sacramento River 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 for being entrained into the interior Delta through open Delta Cross Channel gates following any water quality associated actions (expected to occur in less than 1 in 10 years), although the actual fraction present at the time the gates are physically open is expected to be quite less. 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 main stem 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 main stem channel will allow fish to have shorter transit times to the lower tidal Delta and follow a more direct route to the estuary.

8.6.3.7 Risk to Southern Distinct Population Segment 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 is unknown. The fact that juvenile sDPS green sturgeon may spend an extended period of time rearing in the waterways of the Delta (months to 2-3 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 main stem 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 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 mainstem of the Sacramento River to continue their spawning migration upriver.

8.6.3.8 Delta Cross-Channel Gate Improvements

The Delta Cross Channel radial gates are older structures which require operators to be physically onsite to manually operate the gates in order to open or close them. Increased use could result in the radial gates breaking in either the open or closed positions. Improvements to the Delta Cross Channel would allow greater operational flexibility, faster, automated operations, and increased gate reliability. Without these improvements, the risk of gate failure increases which could lead to higher rates of entrainment of winter-run Chinook salmon, CV spring-run Chinook salmon, or CCV steelhead should the gate fail in an open or partially open position. Further, improved Delta Cross Channel operational flexibility along with improved biological and physical monitoring would likely minimize salmonid routing into the interior Delta with its associated greater level of mortality.

Reclamation proposes to evaluate potential improvements to the Delta Cross Channel gate structure and operating mechanisms.. Future operations of the gates may include diurnal openings with nocturnal closures to take advantage of salmonid migratory behavior which may benefit fish by reducing entrainment potential. This proposed action component will be considered as a programmatic consultation.

8.6.3.9 Delta Cross Channel operations

The proposed action revisions associated with Delta Cross Channel operations that occurred after April, 2019 clarified that December through January Delta Cross Channel openings would be limited to occasions when drought conditions are observed. If drought conditions are observed (i.e. fall inflow conditions are less than 90 percent of historic flows) Reclamation and DWR will consider 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 exceedances. Reclamation and DWR will coordinate with FWS, NMFS and the State Water Resource Control Board on how to balance D-1641 water quality and ESA-listed fish requirements. The final proposed action also includes a new commitment to reduce combined CVP/SWP exports to health and safety levels (NMFS assumes that this is 1,500 cfs) during any Delta Cross Channel gate opening in December or January.

During December and January, a substantial proportion of the juvenile winter-run Chinook salmon cohort may be at risk of entrainment into the Delta Cross Channel, but that additional risk, relative to under current operating scenario conditions, is expected to be realized in less than 10 percent of years but may occur during the term of the opinion. Because these Delta Cross Channel revisions to the proposed action were provided to NMFS earlier than other revisions, the effects are already analyzed in the primary effects section.

8.6.4 North Bay Aqueduct Operations

8.6.4.1 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 (cfs) (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. Growth of biofilm in a portion of the pipeline also limits the North Bay Aqueduct ability to reach its full pumping capacity.

The North Bay Aqueduct intake is located approximately 10 miles from the main stem 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 CDFW and NMFS fish screening criteria. 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 (ft/s). The larger units were designed for a 0.5 ft/s approach velocity, but actual approach velocity is about 0.44 ft/s. The screens are routinely cleaned to prevent excessive head loss, thereby minimizing increased localized approach velocities ("hotspots" on the screen).

8.6.4.2 Deconstruct the Action

Water Diversion - DWR proposes to operate the North Bay Aqueduct intake in the North Delta through the operation of the Barker Slough Pumping Plant to deliver water to the North Delta Aqueduct entitlement holders as has been previously done. Current pumping capacity is limited to 140 cfs due to the functional capacity of the existing pipeline at the facility and the capacity of the existing pumps. The proposed operations of the Barker Slough Pumping Plant also includes a maximum seven-day average diversion rate that would not exceed 50 cfs from January 15 through March 31 of dry and critically dry years (per the current forecast based on D-1641) if longfin smelt are detected at Station 716 during the annual Smelt Larval Survey.

Pumping is typically lower in the winter and early spring (December through April) than in the summer and fall (May through November) (Table 58 and Table 59) and DWR believes there will be no change in the pattern of pumping from what has occurred in the past. An additional pump is required to reach the pipeline design capacity of 175 cfs.

Table 58. 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 59. Average monthly diverted flows in cubic feet per second (cfs) 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 CDFW and NMFS fish screening criteria 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 waterbodies, including Campbell Lake, Calhoun Cut, and Lindsey Slough. It is approximately ten 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 (February 5, 2019; (U.S. Bureau of Reclamation 2019c)) 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.

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. 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 two aggregate base spoil sites located near the pumping plant.

8.6.4.3 Assess Species Exposure to 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 to 2004) in Lindsey Slough or Barker Slough. Captures of juvenile Chinook salmon have occurred in the months of February and March and typically are only a single fish per net haul (CDFG Catch summary). Most juvenile Chinook salmon captured have come from Miners Slough, which is a direct distributary from 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 60 and Figure 110). No steelhead or green sturgeon have been captured in the monitoring surveys from 1996 to 2004, the range of dates available on the CDFW website. Green sturgeon are assumed to occur in the waters of

Cache Slough and the Sacramento ship channel as green sturgeon have been caught in these waters by sport fisherman.

Table 60. Catches of Chinook salmon in the North Bay Aqueduct larval fish survey from 1994 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

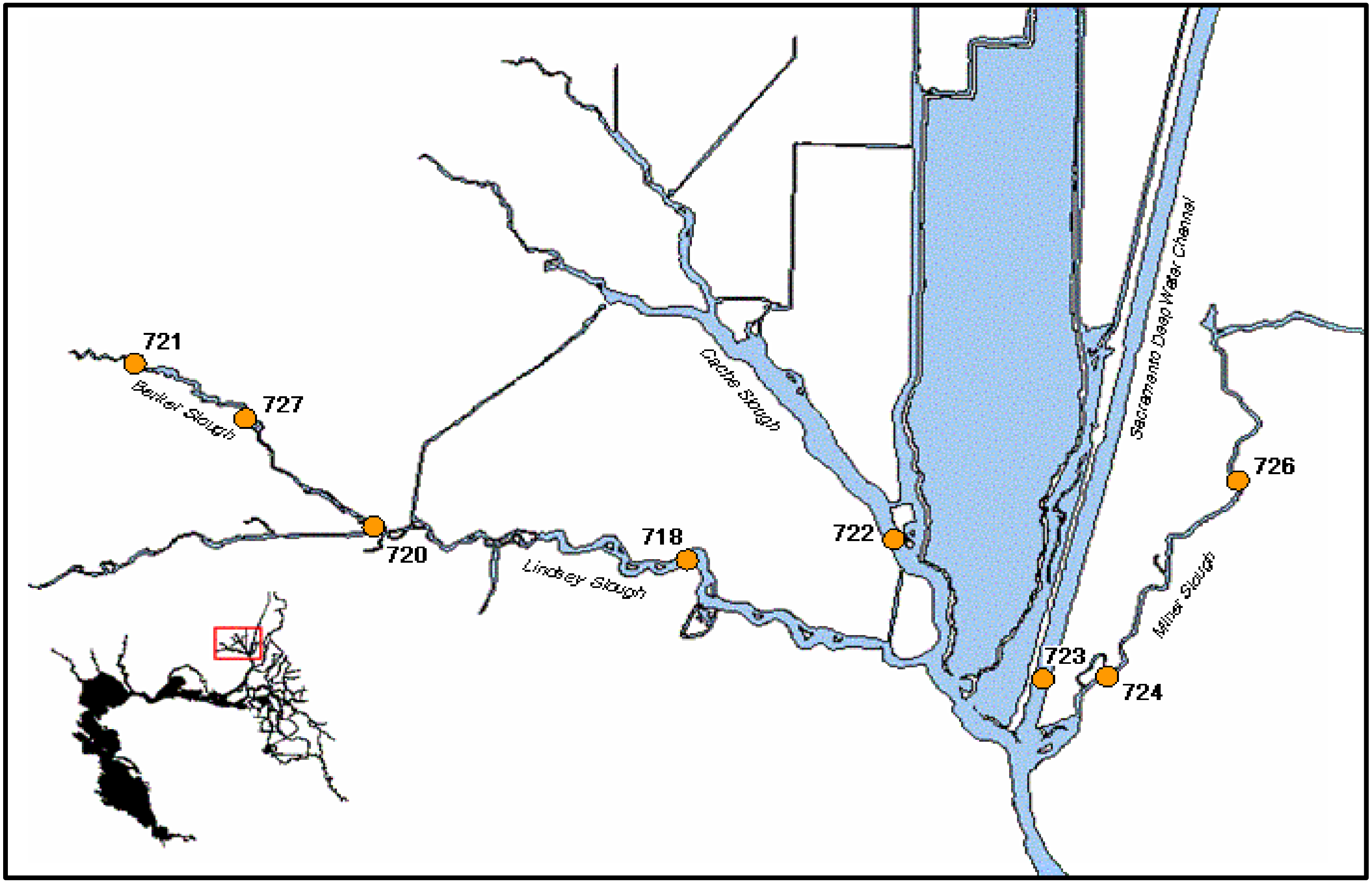


Figure 110. Map of North Bay Aqueduct larval fish survey sampling sites.

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 green sturgeon may use the waters of the Cache Slough complex opportunistically while holding in the Delta, but like adult salmonids, are unlikely to be affected by the screens.

8.6.4.4 Assess Response of Species to the North Bay Aquaduct 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 for the past ten years (2008 to 2018). 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 ten-year period (Table 59). Monitoring by CDFW for the North Bay Aquaduct 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 Barker Slough. 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 migrational corridors utilized by emigrating Chinook salmon and steelhead juveniles in the North Delta system. Green sturgeon may be present in the waters of Lindsey and Barker sloughs since they are present in Cache Slough and the Sacramento Deepwater Ship Channel. Green sturgeon are expected to be fully screened 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 waste 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 or green sturgeon 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 is subsequently deposited in the waste pits to die. As previously stated, if vegetation removal occurs at times when listed salmonids or sDPS green sturgeon 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 or green sturgeon would be present in these shallow waterways.

8.6.4.5 Risk to Listed Salmonids

The presence of listed salmonids (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 one 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 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 salmonids. Therefore, it is unlikely that any fish will be negatively impacted by being present near 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. It is not expected that the proposed action components by DWR to operate the North Bay Aqueduct will alter the current risks to listed salmonids.

8.6.4.6 Risk to Listed Southern Distinct Population Segment Green Sturgeon

For the same reasons described for listed salmonids, the risk of negative 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. sDPS green sturgeon are unlikely to be affected by the cleaning of sediment or aquatic weeds. It is unlikely that they will be present at the fish screen location at any time and particularly during the summer when water temperatures are elevated, and therefore they are unlikely to be present when these cleaning operations are being implemented.

8.6.5 Contra Costa Water District – Rock Slough Operations

8.6.5.1 Description of the Contra Costa Water District/ Rock Slough Intake Infrastructure and Operations

The Contra Costa Water District diverts water from the Delta for irrigation and municipal and industrial uses under its CVP contract, under its own water right permits and license issued by the State Water Resource Control Board, and under East Contra Costa Irrigation District's pre-1914 water right. The Contra Costa Water District water system includes the Mallard Slough, Rock Slough, Old River, and Middle River (on Victoria Canal) intakes; the Rock Slough Fish Screen (constructed in 2011 under the authority of CVPIA 3406(b)(5)); the Contra Costa Canal and shortcut pipeline; and the Los Vaqueros Reservoir. The Rock Slough Intake, Contra Costa

Canal, and shortcut pipeline are currently owned by Reclamation, and operated and maintained by Contra Costa Water District under contract with Reclamation. Mallard Slough Intake, Old River Intake, Middle River Intake, and Los Vaqueros Reservoir are owned and operated by Contra Costa Water District.

The Rock Slough Intake is located about four miles southeast of Oakley. Water is pumped west from Rock Slough through a positive barrier fish screen into the Contra Costa Canal using Pumping Plants #1 through #4. The fish screen at this intake was designed in accordance with the CVPIA and the 1993 FWS Opinion for the Los Vaqueros Project to reduce take of fish through entrainment at the Rock Slough Intake and became operational in 2011. The 1.75-mm-opening, 0.2 ft/s-approach-velocity fish screen installed at the Rock Slough intake is intended to prevent entrainment of listed fish, including juvenile winter-run Chinook salmon, CV spring-run Chinook salmon, and CCV steelhead, into the Contra Costa Canal. The Contra Costa Canal is 48 miles long. Contra Costa Water District's Contra Costa Canal Replacement Project replaces the 4-mile long, earth-lined portion of the Contra Costa Canal between the Rock Slough Fish Screen and Pumping Plant #1 with a buried 10'-diameter concrete pipe. The remaining 44 miles of the Contra Costa Canal after Pumping Plant #1 are concrete-lined. The earth-lined portion of the Contra Costa Canal is subject to water quality degradation due to seepage into the canal from saline groundwater in the area, as well as seepage losses where the groundwater table is lower than canal water levels. Replacing the open channel with a buried pipe also eliminates evaporative losses. Removal of the open water facility also improves public safety, system security, and flood control, which are needed in light of the developing and planned urbanization in the vicinity. As of late 2018, approximately 3 miles of the earth-lined portion of the Canal has been replaced (from Pumping Plant #1 to the east) and the flood isolation structure near the fish screen has also been completed. Pumping Plant #1 has a permitted capacity to pump up to 350 cfs into the Canal. Diversions at Rock Slough Intake are typically taken under CVP contract or under Contra Costa Water District's pre-1914 water right. Contra Costa Water District diverts approximately 30 percent to 50 percent of its total annual supply through the Rock Slough Intake, depending upon water quality in a given year.

8.6.5.2 Deconstruct the Action

Reclamation is consulting on the ongoing operations of the Rock Slough Intake that diverts water from Rock Slough, through the Contra Costa Canal to the pumping plants near Oakley. Contra Costa Water District diverts approximately 127 thousand acre-feet on average from the Delta. Approximately 110 thousand acre-feet is CVP contract supply. Contra Costa Water District operates the Rock Slough Intake together with its other intakes and the Los Vaqueros Reservoir to meet its delivered water quality goals and to protect listed species. The choice of which intake to use at any given time is based in large part upon salinity at the intakes, consistent with fish protection requirements specified in separate opinions that govern operation of Contra Costa Water District's intakes and Los Vaqueros Reservoir.

Reclamation is not consulting on the biological opinions that govern Contra Costa Water District's intakes and Los Vaqueros Reservoir, nor will this consultation amend or supersede those separate biological opinions. For the proposed action (February 5, 2019; (U.S. Bureau of Reclamation 2019c)) component in this consultation, Contra Costa Water District's operations are consistent with the current implementation of the operational criteria specified in those separate biological opinions. Reclamation is requesting incidental take coverage for all water diverted at the Rock Slough Intake up to the maximum capacity of the intake (350 cfs) for the maximum annual diversion of 195 thousand acre-feet. Diversions from 2008 to 2018 have been less than this maximum (Figure 111). During this recent period, diversions at Rock Slough Intake have been limited due to preferential use of Contra Costa Water District's other intakes prior to construction of the Rock Slough Fish Screen, operational outages at the Rock Slough Intake during construction of the Rock Slough Fish Screen and construction of the Contra Costa Canal Replacement Project, water conservation efforts during the drought, and poor water quality at Rock Slough Intake during the drought. The analysis below examines Contra Costa Water District's maximum pumping capacity.

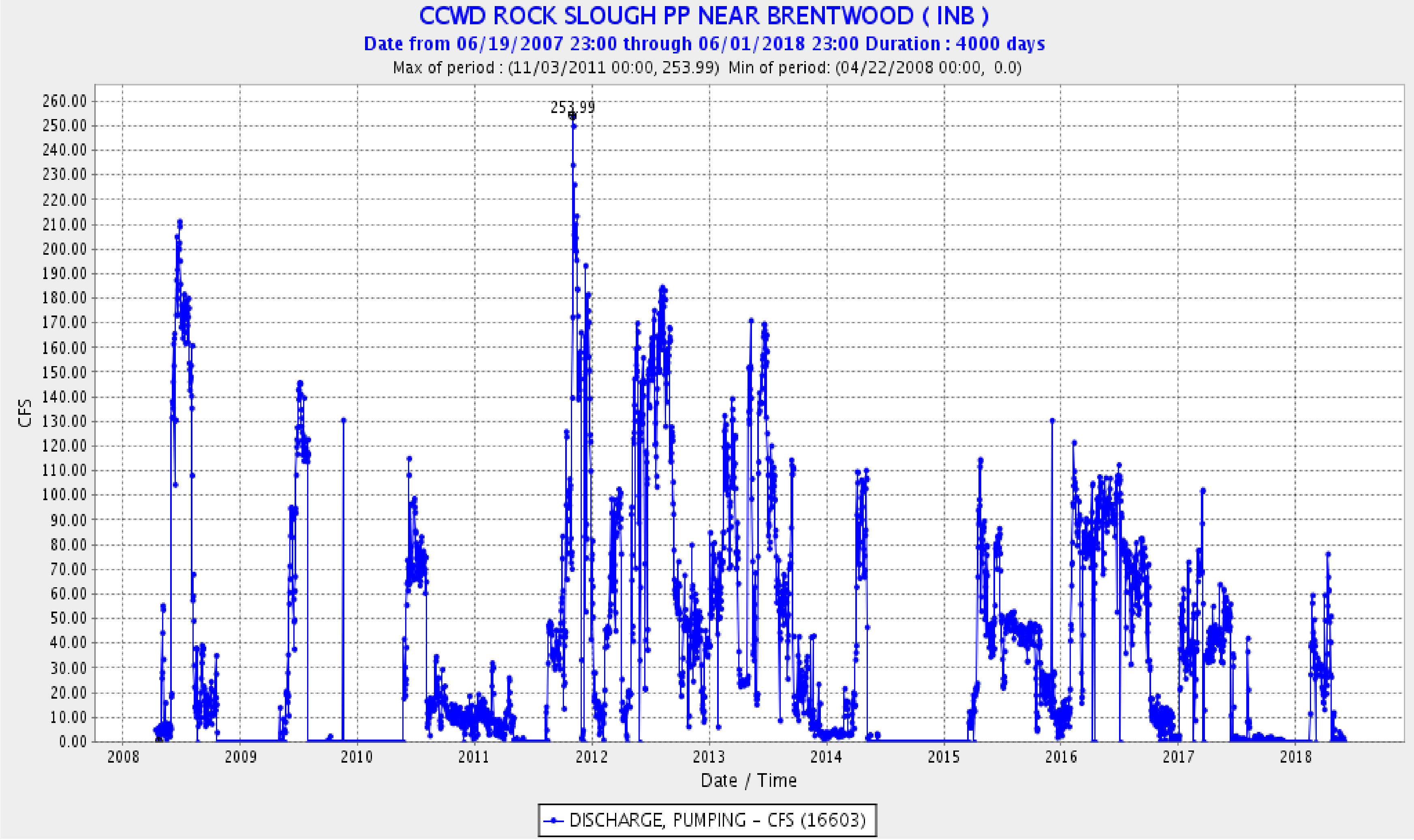


Figure 111. Historical diversion of water through the Contra Costa Water District Rock Slough Pumping Plants 2008 to 2019.

8.6.5.3 Assess Species Exposure to Rock Slough Intake Operations

Juvenile winter-run Chinook salmon are present in the Delta from approximately December through June based on salvage records from the CVP/SWP fish salvage facilities (Table 61). The peak occurrence of juvenile winter-run Chinook salmon in the South Delta is from January through March.

Juvenile CV spring-run Chinook salmon are present in the South Delta, based on salvage records from the CVP/SWP fish collection facilities, from January through June with peak occurrence from March through May (Table 62).

CCV steelhead may also be present in the waters of the South Delta from October through July, based on salvage records from the CVP/SWP fish collection facilities, but have peak occurrence from late February through early April (Table 63). Juvenile and adult sDPS green sturgeon are assumed to be present year-round in the Delta.

Table 61. Timing of unclipped juvenile Sacramento River winter-run Chinook salmon, based on length-at-date, at the salvage facilities for brood years 1994 to 2017.

Brood Year	First Passage Date	5% Passage Date	10% Passage Date	25% Passage Date	50% Passage Date	75% Passage Date	90% Passage Date	95% Passage Date	Last Passage Date	Number Salvaged
Average	**26-Dec**	**9-Jan**	**22-Jan**	**4-Feb**	**24-Feb**	**11-Mar**	**24-Mar**	**29-Mar**	**22-Apr**	**1,210**
Median	18-Dec	4-Jan	25-Jan	14-Feb	2-Mar	14-Mar	24-Mar	31-Mar	21-Apr	811
2017	2/5/18	3/1/18	3/6/18	3/22/18	3/25/18	3/29/18	4/3/18	4/5/18	5/15/18	237
2016	12/20/16	12/20/16	12/20/16	12/27/16	2/14/17	3/29/17	4/5/17	4/24/17	4/24/17	40
2015	12/28/15	12/28/15	1/5/16	1/14/16	1/28/16	2/22/16	3/22/16	3/22/16	3/22/16	36
2014	12/24/14	12/24/14	12/24/14	12/26/14	1/4/15	1/21/15	1/21/15	2/3/15	3/31/15	53
2013	3/3/14	3/5/14	3/6/14	3/9/14	3/15/14	3/20/14	4/4/14	4/10/14	4/14/14	192
2012	12/4/12	12/15/12	12/16/12	12/19/12	3/9/13	3/21/13	3/25/13	3/28/13	4/6/13	271
2011	1/25/12	2/16/12	2/27/12	3/7/12	3/17/12	3/23/12	3/31/12	4/1/12	5/29/12	841
2010	12/3/10	12/7/10	12/29/10	1/29/11	3/1/11	3/14/11	3/20/11	3/23/11	4/13/11	1,703
2009	12/8/09	1/30/10	2/6/10	2/24/10	3/5/10	3/18/10	3/22/10	3/26/10	4/20/10	1,064
2008	12/30/08	1/9/09	2/26/09	3/3/09	3/8/09	3/13/09	3/16/09	3/18/09	4/17/09	582
2007	1/11/08	1/18/08	1/28/08	2/17/08	3/1/08	3/13/08	3/22/08	3/26/08	4/29/08	660
2006	12/18/06	1/22/07	2/8/07	2/25/07	3/2/07	3/9/07	3/24/07	4/3/07	4/22/07	2,764
2005	12/12/05	12/23/05	1/24/06	2/21/06	3/1/06	3/14/06	3/26/06	4/1/06	5/3/06	1,008
2004	1/2/05	1/6/05	1/11/05	2/5/05	3/1/05	3/16/05	3/26/05	4/4/05	4/20/05	469
2003	12/15/03	1/6/04	1/27/04	2/24/04	3/1/04	3/10/04	3/16/04	3/19/04	5/19/04	2,728
2002	12/18/02	12/24/02	12/26/02	1/7/03	2/24/03	3/5/03	3/19/03	3/26/03	5/7/03	2,265
2001	12/5/01	12/13/01	12/18/01	12/31/01	3/5/02	3/25/02	3/31/02	4/6/02	4/27/02	1,442

Brood Year	First Passage Date	5% Passage Date	10% Passage Date	25% Passage Date	50% Passage Date	75% Passage Date	90% Passage Date	95% Passage Date	Last Passage Date	Number Salvaged
2000	12/12/00	2/2/01	2/14/01	2/23/01	3/6/01	3/13/01	3/19/01	3/23/01	4/23/01	5,932
1999	1/2/00	1/26/00	1/28/00	2/12/00	2/19/00	3/17/00	3/30/00	4/3/00	4/14/00	1,924
1998	1/24/99	2/23/99	3/5/99	3/13/99	3/21/99	4/1/99	4/8/99	4/11/99	4/26/99	1,510
1997	12/4/97	12/6/97	12/8/97	12/11/97	1/4/98	3/9/98	3/21/98	3/23/98	3/27/98	726
1996	12/10/96	12/12/96	3/8/97	3/20/97	3/26/97	3/27/97	3/30/97	3/31/97	4/6/97	388
1995	12/18/95	1/2/96	1/7/96	1/16/96	1/25/96	2/7/96	3/16/96	4/2/96	4/18/96	781
1994	12/16/94	12/24/94	12/28/94	1/13/95	1/20/95	1/29/95	4/21/95	4/26/95	5/6/95	1,416

Table 62. Timing of unclipped juvenile Central Valley spring-run sized Chinook salmon, based on length-at-date, at the fish salvage facilities for brood years 1994 to 2017.

Brood Year	First Passage Date	5% Passage Date	10% Passage Date	25% Passage Date	50% Passage Date	75% Passage Date	90% Passage Date	95% Passage Date	Last Passage Date	Number Salvaged
Average	**12-Feb**	**26-Mar**	**31-Mar**	**7-Apr**	**19-Apr**	**28-Apr**	**8-May**	**14-May**	**4-Jun**	**14762**
Median	**19-Feb**	**27-Mar**	**30-Mar**	**6-Apr**	**18-Apr**	**27-Apr**	**7-May**	**13-May**	**4-Jun**	**8832**
2017	3/14/18	3/27/18	3/28/18	3/30/18	4/7/18	4/16/18	5/2/18	5/9/18	5/23/18	9487
2016	2/16/17	4/10/17	4/18/17	4/27/17	5/7/17	5/14/17	5/22/17	6/1/17	6/29/17	26713
2015	2/11/16	2/12/16	2/28/16	3/18/16	4/17/16	5/2/16	5/13/16	5/14/16	5/19/16	158
2014	3/30/15	3/30/15	3/30/15	4/5/15	4/22/15	4/24/15	5/4/15	5/18/15	5/18/15	50
2013	3/13/14	3/19/14	3/21/14	4/5/14	4/9/14	4/19/14	4/23/14	4/29/14	5/10/14	484
2012	3/17/13	3/24/13	3/27/13	4/8/13	4/24/13	5/2/13	5/8/13	5/13/13	5/25/13	909
2011	3/10/12	3/25/12	3/28/12	4/2/12	4/15/12	4/21/12	5/2/12	5/7/12	6/8/12	1063
2010	1/3/11	4/13/11	4/22/11	4/30/11	5/7/11	5/16/11	5/29/11	6/3/11	6/24/11	17654
2009	3/9/10	3/31/10	4/6/10	4/16/10	5/2/10	5/16/10	5/26/10	5/29/10	6/5/10	4068
2008	3/15/09	3/30/09	4/2/09	4/11/09	4/23/09	5/1/09	5/10/09	5/13/09	6/15/09	4730
2007	3/11/08	4/3/08	4/7/08	4/18/08	4/27/08	5/4/08	5/10/08	5/14/08	6/5/08	5100
2006	3/2/07	4/1/07	4/4/07	4/10/07	4/15/07	4/18/07	4/21/07	4/24/07	5/30/07	3378
2005	2/9/06	3/23/06	4/4/06	4/12/06	5/2/06	5/25/06	5/29/06	6/5/06	6/19/06	5822
2004	2/25/05	3/25/05	3/27/05	4/4/05	4/21/05	4/29/05	5/12/05	5/22/05	6/11/05	14694
2003	1/18/04	3/9/04	3/14/04	3/21/04	4/4/04	4/13/04	4/27/04	5/4/04	5/26/04	4534
2002	1/7/03	3/21/03	3/25/03	3/29/03	4/6/03	4/14/03	4/26/03	4/30/03	5/29/03	15706
2001	1/1/02	3/28/02	3/30/02	4/3/02	4/8/02	4/14/02	4/21/02	4/30/02	6/3/02	8177
2000	9/26/00	3/25/01	3/30/01	4/3/01	4/12/01	4/18/01	4/28/01	5/2/01	5/14/01	17940
1999	2/13/00	3/29/00	4/2/00	4/6/00	4/10/00	4/14/00	4/24/00	4/28/00	6/1/00	42468
1998	2/2/99	3/28/99	4/4/99	4/10/99	4/18/99	4/26/99	5/7/99	5/13/99	6/4/99	46655
1997	2/22/98	3/25/98	3/26/98	4/1/98	4/29/98	5/9/98	5/18/98	5/22/98	6/25/98	30589
1996	2/8/97	3/24/97	3/25/97	3/28/97	4/3/97	4/9/97	4/17/97	4/24/97	6/5/97	42906
1995	2/7/96	4/5/96	4/7/96	4/10/96	4/13/96	5/2/96	5/23/96	5/27/96	6/12/96	26785
1994	2/22/95	4/13/95	4/19/95	4/29/95	5/11/95	5/26/95	6/8/95	6/11/95	6/30/95	24224

Table 63. Timing of juvenile unclipped California Central Valley steelhead at the fish salvage facilities for brood years 1998 to 2017.

Brood Year	First Passage Date	5% Passage Date	10% Passage Date	25% Passage Date	50% Passage Date	75% Passage Date	90% Passage Date	95% Passage Date	Last Passage Date	Number Salvaged
Average	**4-Dec**	**23-Jan**	**8-Feb**	**24-Feb**	**19-Mar**	**10-Apr**	**1-May**	**13-May**	**17-Jun**	**1395**
Median	19-Dec	26-Jan	10-Feb	24-Feb	20-Mar	6-Apr	25-Apr	9-May	22-Jun	1074
2017	2/1/18	3/14/18	3/17/18	3/24/18	4/3/18	4/15/18	5/15/18	5/23/18	6/11/18	1119
2016	11/27/16	11/27/16	12/31/16	1/25/17	5/8/17	5/24/17	6/6/17	6/16/17	6/16/17	65
2015	1/20/16	2/1/16	2/2/16	2/16/16	3/15/16	3/25/16	4/3/16	5/2/16	5/23/16	119
2014	11/16/14	11/16/14	2/16/15	2/17/15	2/27/15	4/17/15	4/28/15	5/8/15	5/8/15	43
2013	1/23/14	2/19/14	2/20/14	3/7/14	3/25/14	4/7/14	4/10/14	4/23/14	5/6/14	185
2012	11/23/12	1/22/13	2/12/13	3/22/13	3/31/13	4/26/13	5/13/13	5/27/13	7/2/13	797
2011	9/12/11	1/5/12	3/9/12	3/24/12	3/30/12	4/4/12	4/18/12	4/21/12	6/3/12	342
2010	10/28/10	2/12/11	2/17/11	3/2/11	4/13/11	5/28/11	6/12/11	6/20/11	6/27/11	738
2009	12/20/09	2/3/10	2/6/10	2/10/10	2/23/10	4/2/10	5/31/10	6/19/10	6/21/10	1030
2008	1/25/09	2/11/09	2/20/09	3/2/09	3/16/09	3/30/09	4/28/09	5/11/09	7/7/09	372
2007	1/18/08	1/30/08	2/2/08	2/12/08	2/23/08	3/14/08	4/22/08	5/4/08	7/6/08	984
2006	12/31/06	2/12/07	2/15/07	3/5/07	3/24/07	4/9/07	4/17/07	4/20/07	6/7/07	2774
2005	1/4/06	2/10/06	2/24/06	3/4/06	3/30/06	5/31/06	6/14/06	6/24/06	7/5/06	1601
2004	11/3/04	1/11/05	1/28/05	2/25/05	3/25/05	4/14/05	5/21/05	6/3/05	7/3/05	1351
2003	12/18/03	1/12/04	1/28/04	2/15/04	3/1/04	3/12/04	3/30/04	4/5/04	5/27/04	1785
2002	12/20/02	1/8/03	1/12/03	1/21/03	3/3/03	3/22/03	4/14/03	5/11/03	6/24/03	2189
2001	12/20/01	1/18/02	1/25/02	2/22/02	3/12/02	3/29/02	4/14/02	4/29/02	7/4/02	1632
2000	10/31/00	1/22/01	2/9/01	2/23/01	3/10/01	3/25/01	4/5/01	4/13/01	6/1/01	4610
1999	8/25/99	1/22/00	1/30/00	2/10/00	2/20/00	3/7/00	4/5/00	4/17/00	7/29/00	3866
1998	10/23/98	2/6/99	2/11/99	3/15/99	4/8/99	4/19/99	5/18/99	5/26/99	7/2/99	2292

8.6.5.4 Assess Response of Species to Rock Slough Intake Operations

The positive barrier fish screen was completed and became operational in 2011. The screen is designed to meet both the NMFS and CDFW criteria for preventing salmonids from entrainment and impingement. The operation and maintenance of the fish screen is the subject of its own biological opinion with NMFS and has its own incidental take (National Marine Fisheries Service 2017d). The screen is located approximately 3.6 miles west of the junction of Old River with Rock Slough, and approximately 2.8 miles west of the junction of Werner Cut with Rock Slough.

Listed salmonids can access the fish screen at the terminal portion of the Rock Slough channel from either the route leading from the junction with Old River, which is the most direct route, or by the more circuitous route through Werner Cut which connects with Indian Slough to the south (4.4 miles) and then eastwards to Old River just north of the Highway 4 Bridge (2.4 miles; total distance 6.8 miles). Listed salmonids are known to occur in the Old River channel, and may come from both the northern direction (lower main stem San Joaquin River) or from the south via Middle and Old rivers. Fish that come from the north may originate in the Sacramento River basin, the Mokelumne River basin, the Cosumnes River basin or the San Joaquin River basin, based on observations of listed fish at the CVP/SWP fish salvage facilities. Fish that come from the south would generally originate from the San Joaquin River basin via the Head of Old River, but would have to escape entrainment at the CVP Tracy Fish Collection Facility or SWP's Clifton Court Forebay to travel northwards towards Rock Slough. Fish migrating within the Old River channel would experience tidal forcing into and out of these channels twice daily. Once fish are pushed into the Rock Slough channel, and have moved past the junction between Rock Slough and Werner Cut, they would begin to experience the effects of water diversion by Contra Costa Water District through their Rock Slough facilities. The Rock Slough channel is approximately 600 feet wide at its junction with Old River, then becomes narrower as it approaches the location of the fish screen. The final channel width is approximately 230 feet for the final approach to the fish screen, with a depth of about 10 feet, and is a dead end channel, terminating approximately one-third of a mile west of the fish screen.

Contra Costa Water District diverts water throughout the year, but not at consistent rates. Pumping rates are frequently much less than the permitted maximum. If the Contra Costa Water District diverts at its maximum permitted rate (350 cfs), the estimated average flow velocity in the terminal portion of the Rock Slough channel would be 0.15 feet per second (fps), based on a cross section of 2,300 square feet (230-foot width x 10-foot depth) and the equation Q (volumetric flow rate) = Area (channel cross sectional area) x velocity (average flow velocity). The magnitude of tidal flow would likely be much greater in this channel compared to the velocity generated at the maximum pumping rate. The sustained swimming speed of a juvenile salmonid should be more than adequate to escape the 0.2 fps approach velocity of the screen and the ambient velocity of Rock Slough created by the water diversion.

While listed fish are most likely able to volitionally escape the effects of the fish screen and avoid impingement, the diversion of water and the small increase in net velocity towards the intake canal may delay or inhibit their normal movements and migratory behavior. This would increase their transit time through this region of the south Delta. As previously described in the section regarding the effects of the Delta Cross Channel, and increases in transit times during migration, any increase in transit time has the potential to increase the risk of mortality. This increase is most likely related to an increase in the duration of exposure or the number of predators encountered by a migrating fish. For fish that increase their time remaining within the Rock Slough, the risk of exposure to predator increases. Rock Slough has habitat that is favorable to non-native predators such as striped bass in the open channel waters, and black bass along the channel shorelines. The amount of predator habitat near the Rock Slough Intake has been reduced by the construction of the Rock Slough fish screen that was completed in 2011 (National Marine Fisheries Service 2017d). NMFS anticipates that any listed salmonids present in the Rock Slough would be more vulnerable to predation the longer it remained in those waters.

8.6.5.5 Risk to Listed Salmonids

The Contra Costa Water District has conducted fish monitoring in the Rock Slough channel headworks and within the Contra Costa Canal at Pumping Plant #1 for several decades. Prior to the installation of the positive barrier fish screen (operational in 2011), monitoring efforts collected low numbers of Chinook salmon and steelhead at both the headworks location (adjacent to current fish screen location) and at Pumping Plant #1 downstream in the Contra Costa Canal (Table 64). Since the installation of the positive barrier fish screen in 2011, no salmonids have been observed in fish monitoring behind the screens for the period of 2011 to 2018. The monitoring data from before the installation of the fish screen (1999 to 2011) would indicate that it is possible for salmonids to be present at the location of the fish screen on Rock Slough, but that they would present in low numbers. The potential for salmonids to occur in front of the fish screens during water diversions is anticipated to remain the same under current conditions. The more recent data for sampling behind the fish screen (2011 to 2018) indicate that the screens are functioning as designed, and listed salmonids are unlikely to pass through the screens during water diversions. This indicates that there is a negligible risk to listed salmonids of entrainment through the fish screens during water diversions. It is possible that some impingement may occur due to localized "hot spots" on the screen face developing when aquatic weeds clog the screen face, creating localized high approach velocity regions. The cleaning operations for the fish screen are designed to reduce or eliminate the potential for the creation of "hot spots' along the face of the fish screen.

For any listed salmonid present within the vicinity of the fish screens or within the Rock Slough channel leading up to the fish screens, the risk of predation is elevated the longer they remain in this location.

Table 64. Total number of listed salmonids and green sturgeon collected at the Rock Slough Intake for years 1999 to 2011, prior to the operation of the Rock Slough fish screen.

Species	Number Collected	Number Collected by Year	
		Headworks 1999-2011	Pumping Plant #1 2004-2011
Winter-run Chinook salmon	0	All years - 0	All years - 0
Spring-run Chinook salmon	15 juveniles	2004 - 3 2005 - 4 2006 - 3 2008 - 1	2004 -3 2006 - 1

Species	Number Collected	Number Collected by Year	
		Headworks 1999-2011	Pumping Plant #1 2004-2011
Fall-run Chinook salmon	23 juveniles	2000 - 3 2004 - 5 2005 - 10 2006 - 1 2008 - 2	2004 - 2
Central Valley steelhead	15 juveniles	2005 -4 2006 - 2 2007 - 1 2008 - 8	All years - 0
Green sturgeon	0	All years - 0	All years - 0

Note: No monitoring was conducted at the Headworks in 2010 and 2011 due to the construction of the Rock Slough Fish Screen. Monitoring continued at Pumping Plant #1 until the Rock Slough Fish Screen became operational in October 2011.

8.6.5.6 Risk to Southern Distinct Population Segment Green Sturgeon

The fish monitoring data for both the prescreen period (1999 to 2011) and post screen installation period (2011 to 2018) report that no sDPS green sturgeon have ever been observed in sampling. This would indicate the risk for exposure and potential for entrainment and impingement to the water diversion operations is negligible. It is unlikely that juvenile sDPS green sturgeon would have the same predation risk as listed salmonids, and would see negligible increases in the rate of mortality due to remaining in this waterway for extended periods of time.

8.6.6 Water Transfers

Reclamation and DWR propose to transfer project and non-project water supplies through CVP and SWP south Delta export facilities. The effects of developing supplies for water transfers in any individual year or a multi-year transfer is evaluated outside of this proposed action. Water transfers would occur from July through November in volumes up to those described in Table 4-12 of the ROC on LTO biological assessment (page 4-48; (U.S. Bureau of Reclamation 2019c)). These volumes are the same as those proposed in 2008 by Reclamation for the NMFS 2009 BiOp consultation. The current transfer window extends from July 1 to September 30 of each year. Reclamation and DWR believe that extending the length of the transfer window will enhance the reliability of the water supply by providing greater flexibility to move water through the system when capacity is available at the export facilities. This may provide additional benefits in upstream actions such as improving Sacramento River temperature operations or providing for pulse flows in river reaches below dams when they would be beneficial to tailwater river reaches. Impacts from the proposed changes to the water transfer window include additional flows in Central Valley waterways and increased export levels over current operating conditions in October and November due to diverting transfer water when no additional pumping would have occurred without such transfers being made (i.e., the available capacity). 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 transfers require 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;
- Any upstream impacts to listed species associated with operation of non-CVP/SWP facilities for transfer through the south Delta export facilities will be the subject of their own consultation process;
- This consultation covers the additional duration of the transfer window and the Shasta operations associated with transfers during dry conditions that are intended to support or improve Shasta temperature management. Effects were analyzed assuming a quantity and timing similar to the transfer implemented in 2014.
- This consultation also covers north-to-north transfers along the Sacramento River. Effects were analyzed assuming a quantity and timing of Keswick releases as would occur absent the transfer.

8.6.6.1 Sacramento River Winter-run Chinook Salmon

Neither adult nor juvenile winter-run Chinook salmon are likely to be present in the waters of the Delta during the majority of the proposed water transfer window (July 1 through November 30). There is a low potential for juvenile winter-run Chinook salmon to be present in the Delta during November if early season storms create water flow in the Sacramento River basin to stimulate downstream movements. Likewise, there is a low potential for adult winter-run Chinook salmon to be present in the Delta either at the very beginning of their upstream migration (November) or at the very tail end (late June) of their migration season. If transfer water originates at upstream locations such as Shasta Reservoir, then all life stages may be exposed to the release of waters from the reservoir for transfer through the river to the south Delta export facilities. This upstream exposure would be the subject of a separate consultation process (see assumptions).

In the upper Sacramento River reaches below Keswick Dam, adult winter-run Chinook salmon, incubating eggs, alevins, and emergent fry are likely to be present during the transfer window July 1 through November 30. Adult winter-run Chinook salmon spawn from late-April through mid-August with peak spawning in May and June. Fry emergence occurs from mid-June through mid-October. Once fry emerge, juveniles move to slow moving, channel margin habitats to rear. From July 1 through September 30, only spawning adults, incubating eggs and alevins in the gravel are present in the upper Sacramento River below Keswick Dam. During the period of the water transfer extension (October 1 through November 30), some incubating winter-run Chinook salmon eggs are still in the gravel from late spawning adults, and may remain in the gravel until November until they hatch. The majority of eggs should have hatched by the beginning to middle of October and alevins are either still in the gravel or have emerged as fry to rear in the nearshore areas of the Sacramento River. During October and November, older fry are moving downstream and are observed at the Red Bluff Diversion Dam rotary screw traps.

8.6.6.2 Central Valley Spring-run Chinook Salmon

There is a higher potential for CV spring-run Chinook salmon to be present in the Delta during the proposed water transfer window. Yearling CV spring-run Chinook salmon may be present in the Delta in October and November if upstream precipitation events in tributary watersheds stimulate downstream migration. Adult CV spring-run Chinook salmon may be present in the Delta during the tail end of their upstream migration in late June (and early July). If transfers originate from upstream reservoirs or other forms of water storage in the Sacramento River or San Joaquin River basin tributaries, there is the potential for all life stages to be exposed to the effects of water released for transfers during the July through November transfer window.

CV spring-run Chinook migration into the upper Sacramento River and tributaries extends from mid-March through the end of July with a peak in late May and early June. From July 1 to September 30, adult CV spring-run Chinook salmon are present. CV spring-run Chinook salmon spawning occurs during the first half of September and thus some eggs are present in the gravel during this earlier portion of the water transfer window. Eggs are laid in similarly cool-water reaches of the upper Sacramento as winter-run Chinook salmon. CV spring-run Chinook salmon fry will emerge in mid- to late November, when they are first observed at Red Bluff Diversion Dam. During the period of the water transfer extension (October and November) the majority of spring-run will still be found as incubating eggs in the gravel in the river reaches below Keswick, although some fish have already hatched and emerged from the gravel during the later portion of tis transfer window extension.

8.6.6.3 California Central Valley Steelhead

There is the potential for both adult and juvenile CCV steelhead life stages to be present in the Delta during the proposed water transfer window of July through November. Juvenile CCV steelhead may continue to out migrate through June and into July, based on monitoring data from the Sacramento trawl. Juveniles can also start to be seen again in early fall (October and November) as they migrate downstream into the Delta. This portion of their migration timing represents a small fraction of the population as most juveniles migrate into the Delta in winter. In contrast, most of the annual adult spawning migration into the Sacramento River basin occurs from August through November and would have a large overlap with the water transfer window. Adult CCV steelhead migrating into the San Joaquin River basin would be present in the Delta starting in September and overlap with at least the last 3 months of the transfer window (September through November). Juvenile CCV steelhead rear in the upper Sacramento below Keswick Dam, and in the tailwater sections below the terminal dams in Central Valley tributaries. These fish would be exposed to any water released for the purposes of water transfers. These upstream exposures would be the subject of their own consultation processes (see assumptions).

8.6.6.4 Southern Distinct Population Segment Green Sturgeon

Both juvenile and adult sDPS green sturgeon are expected to be present in the Delta during the entire year. Therefore, they would overlap with the entire proposed period of water transfers (July through November). Likewise, adult and juvenile sDPS green sturgeon would be present in the upper Sacramento and potentially the lower Feather River during the July through November period.

8.6.6.5 Assess Response of Species to the Proposed Water Transfer Window

For those fish present in the Delta during the water transfer window extension, there will be an increase in altered hydrodynamics in waters adjacent to the export facilities as a result of any additional exports to implement a water transfer. The risk of entrainment into the export facilities, coupled with alterations in routing probabilities within the waterways of the central and southern Delta will become more pronounced. The additional level of exports required to divert water for transfer are over and above that which would be normally present without the extended transfer window, as the transfer of water can only occur when there is available export capacity that is not needed for authorized SWP or CVP purposes at the facilities.

Additional risk of entrainment into the fish salvage facilities will increase the risk of mortality to exposed fish. Likewise, alterations in routing paths may increase the travel time or transit distance that a fish must travel to complete its migration behavior. Increases in either of these factors can lead to decreased survival rates through exposure to more predators for a greater distance or for more time (see Delta Cross Channel Operations Section 8.6.3.3 and references therein). These risks are more pronounced for juvenile fish than they are for adult fish.

In contrast to the negative effects of increased export levels upon fish in the vicinity of the CVP and SWP export facilities in the south Delta, changes in flows in the Sacramento and San Joaquin rivers will be generally beneficial to listed fish present during the water transfers. Water released for transfers will augment flows coming into the Delta, providing a shorter transit time in riverine sections of the river channels due to higher flows and velocities. This will decrease the exposure to predators by decreasing the time exposed to the ambient predator field. In addition, higher flows may increase the probability of staying in the "better route" for migration rather than diverting into channels that lead into the Delta interior with their associated lower survival rates. This can be accomplished by offsetting tidal influence in the transition areas between riverine and tidal habitat. Furthermore, additional flows are expected to enhance water quality in the lower reaches of the Sacramento and San Joaquin rivers prior to entering the Delta. Finally, increased flows due to water being released for transfers can provide better migratory cues for adult fish returning on their spawning migrations. These higher flows from tributary watersheds may reduce straying by providing stronger olfactory cues for returning salmonids to find their natal rivers.

In upper Sacramento River sections above the Delta, increased flows during the water transfer window will occur while winter-run and CV spring-run Chinook salmon eggs are still in the gravel incubating, and thus reduce the likelihood of redd dewatering. For those winter-run and CV spring-run Chinook salmon that have emerged from the gravel during the water transfer window, fry and juvenile salmonids will likely move to areas of the river that are inundated by the increased flows, utilizing the increased habitat area for rearing. The flow augmentation for the water transfers from Shasta Reservoir is likely to maintain flows between 3,250 and 6,000 cfs during the fall. Thus, the water transfer releases will not exceed flow thresholds (>12,000 cfs at Wilkins Slough) observed to trigger outmigration of winter-run Chinook salmon past Knights Landing (del Rosario et al. 2013). There is a risk to rearing and migrating fry of stranding in side channels and pools on the inundated streamside bench during ramp down of the reservoir releases. However adherence to the ramping rates required for Keswick Reservoir should minimize or avoid the risk of stranding. Adult CCV steelhead will be exposed to augmented flows which should improve their upstream migratory movements into the reaches below the dams, this is particularly true for the American and Stanislaus rivers. The augmented flows should also increase the rearing area for juvenile CCV steelhead in these rivers, and will also likely improve water temperatures, provided that releases are conducted to maintain or improve water temperatures conditions in the river reaches downstream of the dams.

8.6.6.6 Risk to Listed Salmonids

For Sacramento River winter-run Chinook salmon and CV spring-run Chinook salmon, the overall risk of additional mortality associated with entrainment at the fish salvage facilities or routing into inferior migratory routes due to the water transfer window extension is low. This is primarily due to the lack of temporal overlap with the period of water transfers for most of their life history phases in the Delta (i.e., migrating adult and juvenile life stages, see Table 7 and Table 10). For those winter-run Chinook salmon and CV spring-run Chinook salmon that are present in the Delta during the water transfer window, they are expected to see some benefit from the increased in-river flows created by the release of water for transfer.

Adult CCV steelhead should experience positive effects of increased flows for attracting fish upstream on their migratory spawning runs. During the period from August through November when Sacramento River basin CCV steelhead are moving upstream into the Sacramento River basin, typical river flows are low. Increasing flows will provide stronger migratory cues and stronger olfactory signals to fish moving upriver. Juvenile CCV steelhead, if present, will have a greater risk of entrainment and re-routing into different migratory paths due to export actions. This has the potential to increase mortality within the Delta waterways.

In the upper river reaches, augmented flows during the water transfer window (July – November) will reduce the risk of redd dewatering for winter-run and CV spring-run Chinook salmon by maintaining flows in the river for a longer period. Augmented flows will also improve rearing habitat area size for winter-run and CV spring-run Chinook salmon fry as well as CCV steelhead juveniles, which ultimately may improve juvenile productivity. Flows are not expected to reach levels where downstream migration of winter-run Chinook salmon fry is stimulated after hatching. There is a risk to rearing and migrating fry of stranding in side channels and pools on the inundated streamside bench during ramp down of the reservoir releases. However adherence to the ramping rates required for Keswick Reservoir should minimize or avoid the risk of stranding.

8.6.6.7 Risk to Southern Distinct Population Segment Green Sturgeon

As described in Section 6.7: *Southern Distinct Population Segment (DPS) of Green Sturgeon*, adult, sub-adult, and juvenile sDPS green sturgeon are found within the waters of the Delta year-round. Juvenile sDPS green sturgeon have been observed in salvage at both the Tracy Fish Collection Facility and the Skinner Delta Fish Protective Facility during most months of the year (Table 14) and would overlap with the proposed period of water transfers (July through November). Increased levels of exports to accommodate water transfers would elevate the risk of entraining juvenile sDPS green sturgeon present in the channels of Old and Middle rivers leading to the export facilities.

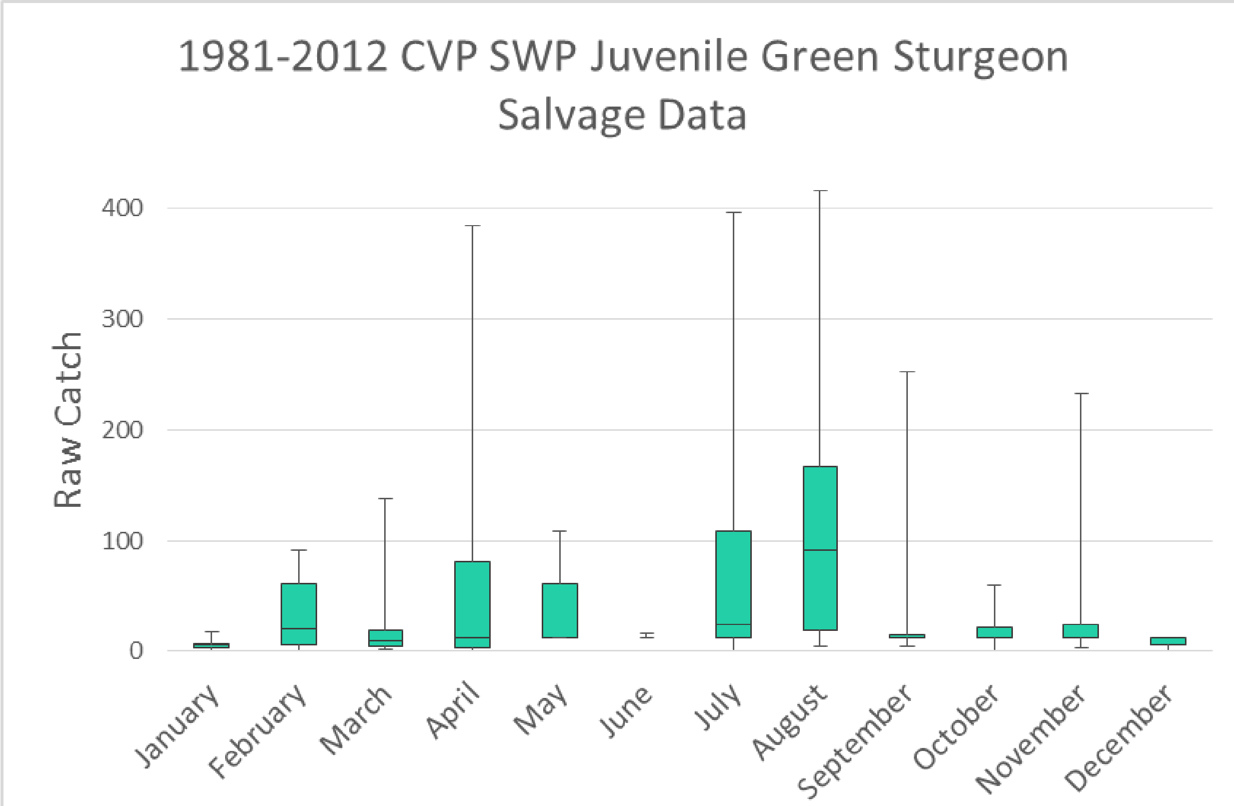


Figure 112. Monthly raw salvage data for juvenile green sturgeon by month at the fish salvage facilities (1981 to 2012).

It is unlikely that the levels of increased exports would increase the risk of entrainment of sub-adult or adult sDPS green sturgeon into the facilities due to the physical barrier created by the trash racks entering the primary louver bays, however, sturgeon may be temporarily detained in front of the trash racks due to the velocity of the water flowing into the facility. At the Tracy Fish Collection Facility, the trash rack is located directly adjacent to the Old River channel, and fish can escape to other parts of the river channel when necessary by swimming against the current. At the SWP, the Clifton Court Forebay is a ~2,500 acre waterbody that functions as a regulating forebay, and sturgeon are first entrained into this waterbody when the radial gates are opened to the Old River channel prior to encountering the trash racks at the Skinner Delta Fish Protective Facility. Adult, sub-adult, and juvenile fish may have long resident times in this forebay after being entrained into Clifton Court Forebay. Inflow velocities at the radial gates are typically quite strong depending on the difference in water surface elevation between Old River and the Clifton Court Forebay, and egress from the forebay is difficult until the flow velocity diminishes as water surface elevations become similar between the two sides of the gate. Any sDPS green sturgeon within Clifton Court Forebay would need to swim through the radial gate structure to escape Clifton Court Forebay and reenter the Delta via Old River when inflow velocities are sufficiently low to permit their upcurrent movement, and before the gates are closed at the end of the tidal cycle.

In other parts of the Delta, adult, sub-adult, and juvenile sDPS green sturgeon may benefit from the increased flow of water into the Delta from upstream releases for water transfers. Higher flows will help transport adults downstream after spawning in the upstream Sacramento River reaches. Likewise, juvenile sDPS green sturgeon migrating downstream will benefit from the enhanced flows. Water quality conditions in the lower river reaches should improve with the additional flow, increasing circulation in these areas and also improving water quality conditions within the Delta.

In the upper river sections of the Sacramento River, the augmented flows are not anticipated to create conditions that stimulate downstream movements of adult and sub adult sDPS green sturgeon beyond the baseline flows without transfers. Migratory behavior in adult and sub adult sDPS green sturgeon is typically stimulated by fall and early winter precipitation events that substantially increase the river flows and decrease ambient water temperatures. It is unlikely that the release of transfer water will be of sufficient volume to increase flows and reduce water temperatures to the degree necessary to stimulate migratory behavior. Furthermore, early movement of adult or sub adult sDPS green sturgeon downstream into the Delta due to augmented flows from water transfers is not anticipated to cause any negative effects to these fish. Juvenile sturgeon typically hold in upriver locations during their first year before migrating downstream into the Delta. These fish hold in upriver locations during flows of much higher magnitude than would be anticipated from the water transfer releases. Thus, there is no anticipated negative impacts from the water transfer releases during the extension period.

8.6.7 Suisun Marsh Salinity Control Gates Operation

The Suisun Marsh Salinity Control Gates are located on Montezuma Slough about two miles downstream of the confluence of the Sacramento and San Joaquin rivers, near Collinsville, California. The Suisun Marsh Salinity Control Gates span 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 Suisun Marsh Salinity Control Gates are in operation, the flashboards are installed at the maintenance channel and the gates are operated tidally.

To evaluate the potential effects of the Suisun Marsh Salinity Control Gates 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 Suisun Marsh Salinity Control Gates. These studies showed that the operation of the Suisun Marsh Salinity Control Gates delays passage of some adult Chinook salmon, while other adult Chinook salmon never pass through the Suisun Marsh Salinity Control Gates 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, the 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 Suisun Marsh Salinity Control Gates 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 Suisun Marsh Salinity Control Gates operation 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).

The purpose of gate operation is to decrease the salinity of the water in Montezuma Slough to meet salinity standards set by the State Water Resource Control Board and Suisun Marsh Preservation Agreement. The Suisun Marsh Salinity Control Gates control salinity by lowering gates during flood tides to prevent 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, Suisun Marsh Salinity Control Gates operation occurs from October to May (~10-20 days) 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 Suisun Marsh Salinity Control Gates operation to allow for continuous Chinook salmon passage opportunity. 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. As of 2018, gates are operated during August in "below normal" or "above normal" water years in addition to October to May operation.

8.6.7.1 Deconstruct the Action - Proposed Suisun Marsh Salinity Control Gates Operation

In addition to the October through May operation to meet Suisun Marsh water quality standards, Reclamation proposes operating the Suisun Marsh Salinity Control Gates on the tidal cycle in below-normal and above-normal years in June through September for 60 days, not necessarily consecutive, to improve Delta Smelt critical habitat. Under the proposed action (February 5, 2019; (U.S. Bureau of Reclamation 2019c)) component, Reclamation and DWR would increase tidal operations of the Suisun Marsh Salinity Control Gates to direct more fresh water in Suisun Marsh to reduce salinity, increase food, and improve habitat conditions for Delta smelt. This would be combined with Roaring River Distribution System management for food production and flushing freshwater through the Roaring River Distribution System to increase the low salinity habitat in Grizzly and Honker bays. Reclamation and DWR will continue to meet existing D-1641 salinity requirements in the Delta and Suisun Marsh.

8.6.7.2 Assess Species Exposure to Proposed Suisun Marsh Salinity Control Gates Operation

The boat lock portion of Suisun Marsh Salinity Control Gates is held open at all times during Suisun Marsh Salinity Control Gates operation to allow for continuous salmonid passage opportunities. With increased understanding of the effectiveness of the gates at lowering salinity levels in Montezuma Slough, salinity standards have been met with less frequent gate operation compared to the early years of operations. The proposed action component would continue Suisun Marsh Salinity Control Gates operation for up to 20 days in October to May, plus an additional 60 days during June to September in above normal and below normal years. 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.

8.6.7.3 Risk to Salmonids

The principal potential effect of the Suisun Marsh Salinity Control Gates being closed for up to 20 days per year from October through May, plus an additional 60 days per year from June to September, is delay of upstream-migrating adult 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 of the boat lock improved passage rates of acoustically tagged adult Chinook salmon, and that even with the gates opened, ~30-40 percent of fish returned downstream. Adult salmonids that do not continue upstream past the Suisun Marsh Salinity Control Gates 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 Suisun Marsh Salinity Control Gates will not be operated and no fish passage delays due to the gates are anticipated. However, during the annual 10-20 days of periodic operation, individual adult salmonids and sDPS green sturgeon may be delayed in their spawning migration from a few hours to several days. The effect of this delay is not well understood. 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. CCV steelhead migrate upstream as their gonads are sexually maturing and a delay in migration may negatively impact their reproductive viability. CV 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. CV spring-run Chinook salmon generally utilize high stream flow 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, particular 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.

Under the proposed action relative to current operations, operation of the Suisun Marsh Salinity Control Gates would increase by 60 days per year during the months of June to September in above normal and below normal years. This additional gate operation during the summer and early fall months is 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 Suisun Marsh Salinity Control Gates is held open at all times during Suisun Marsh Salinity Control Gates operation 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 Suisun Marsh Salinity Control Gates while the boat lock is closed for vessel passage, but salmonids could backtrack around the structure. The proportion of individuals that would do so is uncertain, and as described above, CV spring-run Chinook salmon and CCV steelhead would likely experience greater negative effects than 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 Suisun Marsh Salinity Control Gates. 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 Suisun Marsh Salinity Control Gates 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 Suisun Marsh Salinity Control Gates to only periods required for compliance with salinity control standards, and this operational frequency is expected to be 10-20 days per year. Therefore, the Suisun Marsh Salinity Control Gates will not provide the stable environment which favors the establishment of a local predatory fish population and the facility is not expected to support conditions for an unusually large population of striped bass and pikeminnow. In addition, most listed Central Valley 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.

8.6.7.4 Risk to Southern Distinct Population Segment Green Sturgeon

Little is known about adult sDPS green sturgeon upstream passage at the Suisun Marsh Salinity Control Gates, with existing studies suggesting that Suisun and Honker bays are more utilized than Montezuma Slough where the Suisun Marsh Salinity Control Gates are located. NMFS anticipates that adult sDPS green sturgeon would have the opportunity to pass the Suisun Marsh Salinity Control Gates through the boat lock or gates (when open), as adult salmonids do, but that they could be delayed. sDPS 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. Thus, any delays would not affect access to spawning habitat in the upper Sacramento River because adult sDPS green sturgeon tend to spawn in deeper water (Poytress et al. 2015) that would not be affected by temporary changes in flow. In addition, previous concerns regarding potentially delaying arrival at Red Bluff Diversion Dam (where passage was previously restricted) no longer apply, because the Red Bluff Diversion Dam gates are up year-round, allowing unimpeded passage. The potential for predation near the Suisun Marsh Salinity Control Gates 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 Suisun Marsh Salinity Control Gates.

8.6.8 South Delta Export Operations

In the analysis of this proposed action (February 5, 2019; (U.S. Bureau of Reclamation 2019c)) component, NMFS considers two primary categories of effects in the south Delta due to water export: (1) entrainment and loss 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. The effects related to 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, include the impacts to listed fish travel time, outmigration, behavior changes, and juvenile survival from south Delta hydrodynamics.

Water is diverted at two main facilities in the South Delta for export to regions south of the Delta and to the areas immediately adjacent to the Delta, including portions of the Bay area. The CVP operates the Jones Pumping Plant, the Delta Mendota Canal, and the Tracy Fish Collection Facility. The SWP operates Clifton Court Forebay, the Skinner Delta Fish Protective Facility and the Banks Pumping Plant.

Key water-project-related drivers of south Delta hydrodynamics are Vernalis inflow, CVP and SWP exports from the south Delta export facilities, and the presence or absence of the Head of Old River Barrier; 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 modeling of the proposed action and current operating scenario conditions reflects those realities and, while those scenarios are appropriate for project analysis, they have limited value for evaluating the isolated effects of one driver vs. another. Recently, the Salmonid Scoping Team, a technical team associated with the Collaborative Adaptive Management Team process, evaluated how the relative influence of these drivers on hydrodynamic conditions varied temporally and spatially throughout the south Delta, ((Salmonid Scoping Team 2017a): 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. While the specific combinations of drivers in the Salmonid Scoping Team (2017a) analysis are not necessarily representative of any specific proposed action scenario, these scenarios cross factor individual drivers in a way that allows the evaluation of trends that are relevant to the proposed action. Key findings, with examples of relevance to effects of south Delta operations under the proposed action, include:

- The major river channel distributaries in the south Delta (San Joaquin, Old, and Middle rivers) transition from a riverine environment to a tidally-dominated environment in the Delta. The effect of tides decreases with increasing distance upstream on the main stem river channels, and the tidally dominated region varies with Delta inflow, exports, and tidal phase.

- The hydrodynamic effect of increases in Delta inflow on flow and velocity in the south Delta is greatest at the upstream reaches of the major river channels; diminishes with distance downstream through the Delta or away from the main stem rivers (i.e., into the interior Delta); and is affected by barriers, tidal phase, and exports.

The hydrodynamic effect of exports on flow and velocity in the south Delta is strongest in Old River near the export facilities, in Middle River at Victoria Canal, and the downstream ends of Turner Cut, and Columbia Cut; and it is affected by tidal phase, Delta inflow, distance from the exports, and barriers. South Delta exports in the proposed action are expected to have the stronger effects in DSM2 channels 89 (Old River downstream of the south Delta export facilities) and DSM2 channel 143 (Middle River near Woodward Island) compared to locations on the main stem San Joaquin River (DSM2 channels 45 and 49), as shown in the velocity density overlap plots (Figure 113, Figure 114, and Figure 115).

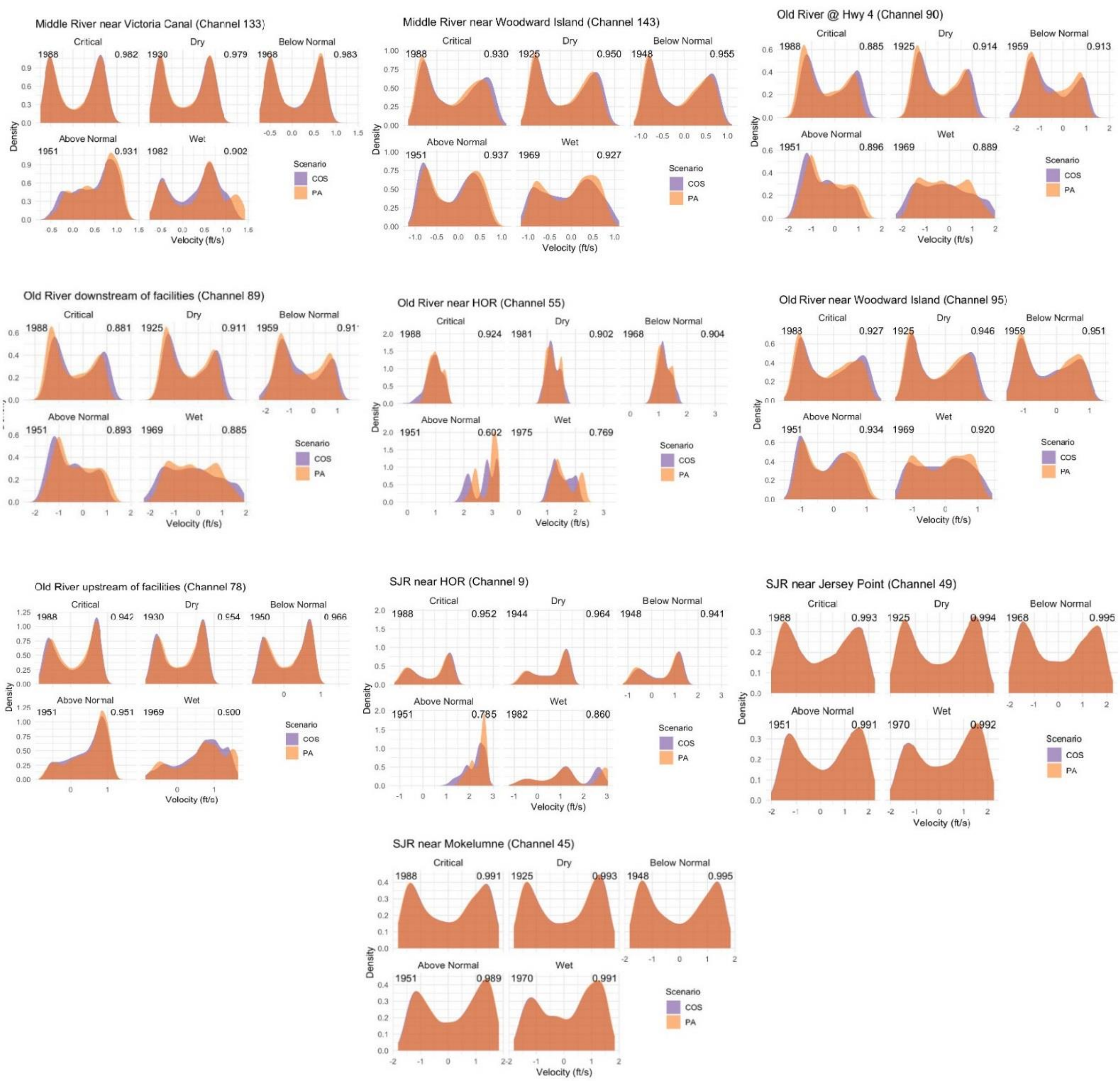


Figure 113. Velocity Density Plots for different locations in the South Delta: December through February Plots.

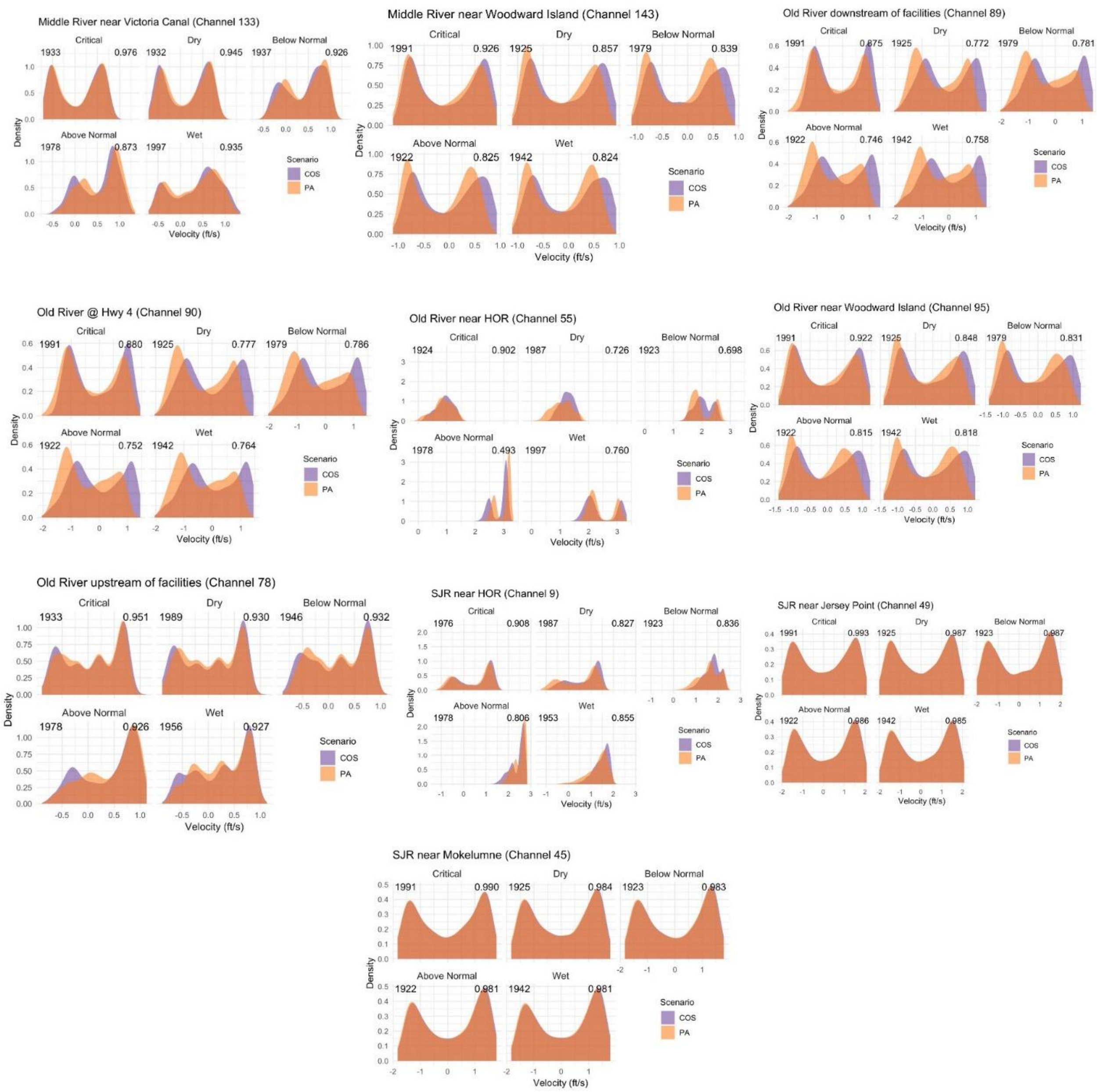


Figure 114. Velocity Density Plots for different locations in the South Delta: March through May plots.

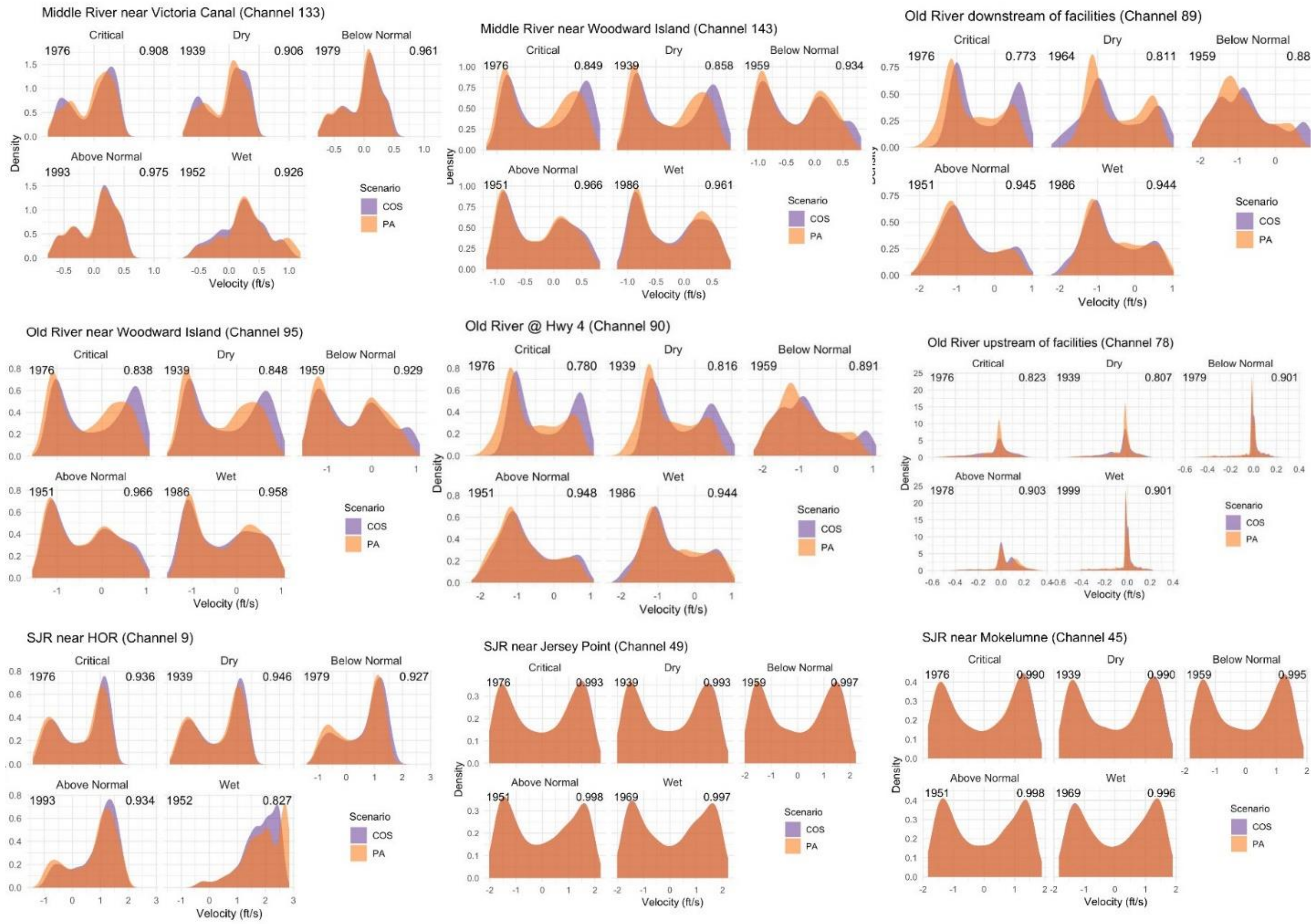


Figure 115. Velocity Density Plots for different locations in the South Delta: June through August plots.

The Delta flow regime can have effects on a wide range of factors, such as productivity, food webs, or invasive species, and management actions related to CVP and SWP operations, which are just a few of many interacting drivers (Delta Independent Science Board 2015; Monismith et al. 2014).

The effects of south Delta export operations on listed winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon are described below (Figure 116). Export effects in the south Delta 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 in the export facilities, or via 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). Export effects of ongoing diversions from the south Delta export facilities negatively impact hydrodynamic conditions in the south Delta, and impacts are modeled to increase in the proposed action compared to the current operating scenario as exports are increased, particularly in April and May.

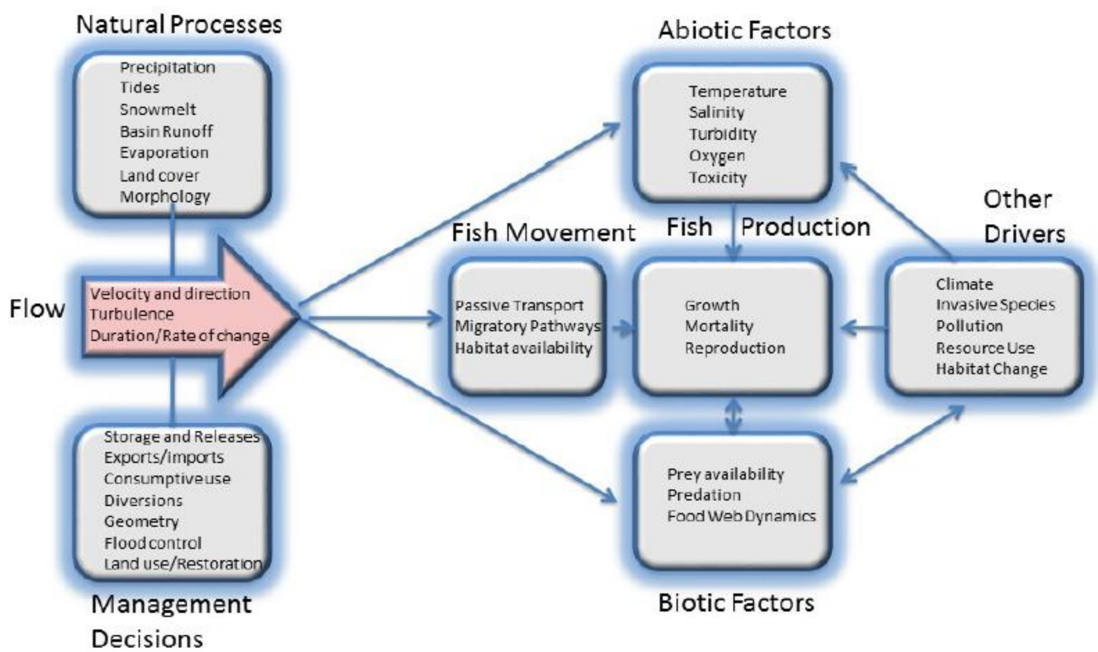


Figure 116. Detailed Conceptual Diagram of the Linkages Between Flows and Fishes in the Delta.

Source: Appendix B from (Delta Independent Science Board 2015)

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. Salmonid Scoping Team (2017a) and Salmonid Scoping Team (2017b) 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)). While those reports did not evaluate specific elements of the proposed action, they were designed to 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 to understanding effects of south Delta operations in the proposed action. Some overarching findings, summarized in the Executive Summary from Volume 1 (Salmonid Scoping Team 2017a), 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 negative 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. The final two findings relate to uncertainties and highlight the need for continued evaluation and testing of hypotheses linking project-related effects on hydrodynamics to biological responses, ideally in a formal adaptive management program.

8.6.8.1 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 (<200 mm) 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 travelling 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 (fps) from May 15 through October 31, and for salmon of approximately 3 fps 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 (JPP) dictates the flow and velocity at the Tracy Fish Collection Facility. There are 6 units at JPP but a maximum of 5 can used; each unit increases the velocity through the Tracy Fish Collection Facility primary channel about 0.5 ft/sec. For juvenile Chinook salmon, the most recent whole facility efficiency evaluations completed using acoustic tag telemetry suggests that primary louver efficiency ranges from 50-100 percent with an average of approximately 88.7 percent (Karp et al. 2017; Wu and Fullard 2018). At higher pumping regimes of 4-5 JPP units, for juvenile Chinook salmon, louver efficiency was high at 71.4-100 percent (Karp et al. 2017).

Sutphin and Bridges (2008) has indicated that under the low pumping regimen required by the Vernalis Adaptive Management Plan (VAMP) 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 (>1) cannot be maintained simultaneously with the secondary channel velocities (3.0 to 3.5 fps 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 green sturgeon is unknown, although apparently 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 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. Current studies at the University of California at Davis are testing louver screening efficiencies for sturgeon using sections of louver panels from the south Delta facilities.

“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 have 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 (PDAT).

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- 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).

Loss due to cleaning is not quantified in the current loss calculation, and therefore, 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. There is a Tracy Fish Facility Improvement Plan (TFFIP) study plan being developed to study the amount of loss occurring during louver cleaning.

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. Generally, each primary louver panel is lifted and lowered back into place three times per day (generally at 600-0800, 1400-1600, and 2300-0100 hours), although frequency of cleaning may be increased or decreased according to pumping rate and debris loads. It takes approximately 3-7 minutes to lift, spray clean, and lower each louver panel back into place. While export pumping may be reduced to address damaged louver panels, issues during cleaning, or other maintenance scenarios where facilities are not capable of effectively salvaging fish, complete shutdown of pumping usually does not occur due to issues related to the primary louvers. At a minimum, all 36 louver panels are cleaned 2-3 times a day but during heavy debris loads, operators clean 3-6 times a day. The 2018 louver cleaning data (see below) suggests less frequent cleaning is required in early summer (low averages of 60 minutes per day) and much higher during the winter months (high averages of 440 minutes per day). This means that there is a gap in the louver panels ranging from 1 to 7.5 hours per day depending on season, pumping rates, and debris loads.

Data from Cleaning Primary Louvers (2018)

Month	Average daily (minutes)
January	240
February	131
March	112
April	64
May	76
June	138
July	274
August	310

September	200
October	440
November	270
December	370

Secondary bypasses are not cleaned, although they are shut down during the cleaning of the primary louvers to prevent excessive debris from entering the holding tanks.

Fish salvage occurs at the Tracy Fish Collection Facility year-round, except during temporary outages and maintenance activities. 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 every 120 minutes. The number of each species of fish collected in the subsample is determined and then multiplied by 4 (120 pumping 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 period. Pumping 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.

If no Chinook salmon, steelhead, or Delta smelt are salvaged, other species of fish can be maintained in Tracy Fish Collection Facility holding tank 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 fish count, salvaged fish may only be held in Tracy Fish Collection Facility holding tanks for up to 8 hours. When fish can be maintained in Tracy Fish Collection Facility holding tanks for 24 hours, fish transport (fish-haul) generally occurs at approximately 0700 each day. When 2 fish hauls per day are necessary, fish hauls generally occur at 0700 and 2130 each day. When 3 fish hauls are necessary, they are usually completed at 0700, 1500, and 2130 each day. The frequency of fish hauls is also dictated by the Bates Tables which uses size classes, species, and water temperature as indicators for when to conduct a fish haul.

During normal operations, salvaged fish are transported approximately 49.9 km and released at one of two Reclamation release sites near the confluence of the Sacramento and San Joaquin rivers (Antioch Fish Release Site and Emmaton Fish Release Site). In general, the Emmaton Fish Release Site is used for fish hauls performed during daytime hours and the Antioch Fish Release Site is used for fish hauls performed during nighttime hours. This is done for safety and security reasons as the Antioch Fish Release Site has a gate that can be locked behind the operator after he/she enters the release site area. 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. Salmon loss is less than two percent for salmon smaller than 100 mm and zero percent for salmon larger than 100 mm (Aasen 2013).

Estimates of post-release survival and mortality are currently not available, although release site survival and mortality is being investigated by Reclamation (Fullard et al. 2018) and results are anticipated within the next couple of years. It is anticipated that loss to predation is the main source of post release mortality.

8.6.8.2 Skinner Delta Fish Protective Facility

The John E. Skinner Delta Fish Protective Facility was built in the 1960s and 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 Clifton Court Forebay, 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 Clifton Court Forebay through the radial gates, it first passes a floating debris boom before reaching the trashrack. 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 trashrack (vertical steel grates with two-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 comprised 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 eight hours, depending on the density of salvaged fish and the presence of listed species.

Like 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 ten 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 steelhead using releases of PIT-tagged hatchery steelhead released at the Skinner Delta Fish Protective Facility trash rack. The study reported two estimates of efficiency; 74 percent (range 17 to 100 percent) and 82 percent (range 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 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 (range 77.9 to 86.2

percent) and 55.0 percent (range 54.3 and 55.7 percent) for "Salmon" and "Striped Bass" Operating Criteria, respectively.

"Pre-screen loss" is the estimated loss of fish from the radial gates at the entrance to the Clifton Court Forebay to the trash rack in front of the primary louver bays at the Skinner Delta Fish Protective Facility. The pre-screen loss estimates for Chinook salmon developed in the past 10 years are largely consistent with the historical studies outlined in Gingras (1997), which ranged from 63-99 percent. Clark et al. (2009) calculated pre-screen loss rates from paired releases of PIT and acoustic tagged fish released at the Clifton Court Forebay 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 emigration of tagged fish from Clifton Court Forebay). 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 Clifton Court Forebay 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 Clifton Court Forebay radial gates and at the head of the Skinner Delta Fish Protective Facility. Pre-screen loss was estimated as 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 and 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 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 coinciding with NMFS 2009 Opinion RPA Action IV.2.1 (previously VAMP). During other periods, export capacity of the facility is reduced accordingly.

The duration and frequency of louver cleaning operations fluctuates 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 30-60 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 each bay are opened rapidly to flush predators and debris into a holding tank for removal.

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. 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, as was done at the Tracy Fish Collection Facility. Fish are transported to release sites on the San Joaquin River near Antioch, and on the Sacramento River near Horseshoe Bend.

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. No attempt has been made to quantify post-release survival due to logistical challenges and because it likely fluctuates wildly based on a number of factors including, but not limited to, the number of fish being released, season, and frequency of release. Raquel (1989) found that survival rates for Chinook salmon were never less than 98 percent and, in most cases, was 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 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.

8.6.9 Old and Middle River Flow Management

Note that supplemental analysis based on proposed action revisions received June 14, 2019 is provided in Section 8.6.12.9.

Reclamation and DWR propose to operate the CVP and SWP in a manner that maximizes exports while minimizing entrainment of fish and protecting critical habitat. Net Old and Middle River flow provides a surrogate indicator for how export pumping at Banks and Jones Pumping Plants influence hydrodynamics in the south Delta. Reclamation proposes to manage Old and Middle River, in combination with other environmental variables, to minimize the entrainment of fish in the south Delta and at CVP and SWP fish salvage facilities. Reclamation and DWR propose to maximize exports by incorporating real-time monitoring of fish distribution, turbidity, temperature, hydrodynamic models, and entrainment models into the decision support for the management of Old and Middle River to focus protections for fish when necessary and provide flexibility where possible, consistent with the WIIN Act Sections 4002 and 4003, as described below. Estimates of species distribution will be described by multi-agency Delta-focused technical teams. Reclamation and DWR will make a change to exports within 3 days of a trigger when monitoring, modeling, and criteria indicate protection for fish is necessary.

The following Old and Middle River Flow Management description is from the April 30, 2019 proposed action (U.S. Bureau of Reclamation 2019a); the primary difference from the February 5, 2019 proposed action (U.S. Bureau of Reclamation 2019c) is in the additional details for "Storm-related Old and Middle River Flexibility" and corrections of Old and Middle River flow requirements in the Integrated Early Pulse Protection and Turbidity Bridge Avoidance subsections.

- Reclamation and DWR propose to operate to an Old and Middle River index computed using an equation. An Old and Middle River index allows for short-term operational planning and real-time adjustments.
- Old and Middle River Management: From the onset of Old and Middle River management to the end, Reclamation and DWR will operate to an Old and Middle River index no more negative than a 14-day moving average of -5,000 cfs unless a storm event occurs (see below for storm-related Old and Middle River flexibility). Old and Middle River could be more positive than -5000 cfs if additional real-time Old and Middle River restrictions are triggered as described below.
- Onset of Old and Middle River Management: Reclamation and DWR shall start Old and Middle River management when one or more of the following conditions have occurred:
    - Integrated Early Winter Pulse Protection ("First Flush" Turbidity Event): When the running 3-day average of the daily flows at Freeport is greater than 25,000 cfs and the running 3-day average of the daily turbidity at Freeport is 50 NTU or greater for the period from December 1 through January 31, Reclamation and DWR propose to reduce exports for 14 consecutive days so that the 14-day averaged Old and Middle River index for the period shall not be more negative than -2,000 cfs. This "First Flush" action may only be initiated once during the December through January period to limit the CVP/SWP influence on delta smelt's population-scale migration/dispersal. The action will not be required if: 1) the Freeport flow and turbidity conditions are met after January 31, or 2) water temperature reaches 12 °C (53.6 °F) based on a three station daily mean at Honker Bay, Antioch, and Rio Vista, or 3) when ripe or spent delta smelt are collected in a monitoring survey.
    - Salmonids: After January 1, if more than 5 percent of any one or more salmonid species (natural origin young-of-year winter-run Chinook salmon, natural origin young-of-year CV spring-run Chinook salmon, or natural origin CCV steelhead) are estimated to be present in the Delta as determined by their appropriate monitoring working group based on available real-time data, historical information, and modeling.

- Additional Real-Time Old and Middle River Restrictions: Reclamation and DWR shall manage to a more positive Old and Middle River than -5,000 cfs based on the following conditions:
    - Turbidity Bridge Avoidance ("South Delta Turbidity"): In years when a "First Flush" occurs, once Delta smelt have dispersed, there is no evidence that large, population-scale movements continue. This action begins after the completion of the Integrated Early Winter Pulse Protection (above) or February 1, whichever comes first. The purpose of this action is to avoid the formation of a continuous

turbidity bridge from the San Joaquin River shipping channel to the fish facilities, which historically has been associated with elevated salvage of Delta smelt. Reclamation and DWR propose to manage exports in order to maintain daily average turbidity in Old River at Bacon Island at a level of less than 12 NTU. If turbidity does not exceed 12 NTU at Old River at Bacon Island, then there will be no explicit limit on Old and Middle River flow for the purposes of protecting Delta smelt. If daily average turbidity at Old River at Bacon Island cannot be maintained at less than 12 NTU, the 3-day averaged Old and Middle River index shall not be more negative than -2,000 cfs, until the 3-day average turbidity at Old River at Bacon Island drops below 12 NTU. The action is to be taken from February 1 through March 31 even if the Integrated Early Winter Pulse Protection action has not occurred earlier in the water year. The action will no longer be required on or after April 1.

- Larval and Juvenile Delta Smelt: When Q-West is negative and larval or juvenile Delta smelt are within the entrainment zone of the pumps based on real-time sampling, Reclamation and/or DWR propose to run hydrodynamic models informed by the Enhance Delta Smelt Monitoring program (EDSM), 20 mm trawl survey (20 mm) or other relevant survey data to estimate the percentage of larval and juvenile Delta smelt that could be entrained, and operate to avoid no greater than 10 percent loss of modeled larval and juvenile cohort Delta Smelt (typically this would come into effect beginning the middle of March).
- Natural origin CCV steelhead Protection: Reclamation and DWR would operate to an Old and Middle River flow of -2,500 cfs for 5 days whenever more than 5 percent of steelhead are present in the Delta and the natural-origin steelhead loss trigger exceeds 10 steelhead per thousand acre-feet (combined loss at the CVP and SWP). The timing of this action is intended to provide protections to San Joaquin origin CCV steelhead, but the loss-density trigger is based on loss of all steelhead since there is currently no protocol to distinguish San Joaquin-basin and Sacramento-basin steelhead in salvage. Reclamation would use the current loss equation for steelhead or a surrogate. This action will no longer be required after May 31.
- Salvage or Loss Thresholds: Reclamation and DWR propose a cumulative annual salvage loss threshold equal to 1 percent of the abundance estimate based on EDSM for adult Delta smelt; 1 percent of the winter-run Chinook salmon Juvenile production estimate (juvenile production estimate) (genetically confirmed) or 2 percent of the winter-run Chinook salmon juvenile production estimate (based on length at date); loss equal to 1 percent of the CV spring-run Chinook salmon juvenile production estimate (or 0.5 percent of yearling Coleman National Fish Hatchery late fall-run spring-run surrogates); the salvage of 3,000 unclipped juvenile CCV steelhead, and the salvage of 100 juvenile sDPS green sturgeon. Reclamation and DWR may operate to a more positive Old and Middle River when the daily salvage loss indicates that continued Old and Middle River of -5,000 cfs may exceed the cumulative salvage loss thresholds as described below:
    - Restrict Old and Middle River to a 14-day moving average Old and Middle River index of -3,500 cfs when a species-specific cumulative salvage or loss

threshold exceeds 50 percent of the threshold. The Old and Middle River restriction to -3,500 cfs will persist until the species-specific off ramp is met.

- Restrict Old and Middle River to a 14-day moving average Old and Middle River index of -2,500 cfs (or more positive if determined by Reclamation) when a cumulative salvage or loss threshold for any of the above species exceeds 75 percent of the specific threshold. The Old and Middle River restriction to -2,500 cfs will persist until the species-specific off ramp is met.

Species specific Old and Middle River restrictions will end when the individual species-specific off ramp from "End of Old and Middle River management criteria," below, are met.

- Storm-Related Old and Middle River Flexibility: If Reclamation and DWR are not implementing additional real-time Old and Middle River restrictions, consistent with other applicable legal requirements, Reclamation and DWR may operate to a more negative Old and Middle River up to a maximum (otherwise-permitted) export rate at Banks and Jones Pumping Plants of 14,900 cfs (which could result in a range of Old and Middle River values) to capture peak flows during storm-related events. Reclamation and DWR will continue to monitor fish in real-time and will operate in accordance with "Additional Real-time Old and Middle River Restrictions," above.

  Under the following conditions, Reclamation and DWR would not cause Old and Middle River to be more negative for capturing peak flows from storm-related events.

  - Additional real-time Old and Middle River restrictions, above, are triggered, then Reclamation would operate in accordance with those additional real-time Old and Middle River restrictions and would not cause Old and Middle River to be more negative for capturing peak flows from storm-related events.
  - Actual cumulative expanded salvage of Delta Smelt is greater than 50 percent of the average smelt index over the prior three years of non-zero FMWT surveys and a Cumulative Salvage Index of 7.98 during December 1 – January 20 or cumulative expanded salvage of Delta Smelt is greater than or equal to 75 percent of the average smelt index calculated described above.
  - Predicted adult or juvenile Delta Smelt salvage would exceed 50 percent during December 1 – January 20 or cumulative expanded salvage is greater than or equal to 75 percent as determined above, based on the data sources in the Secretarial Memo dated January 17, 2019.
  - Measured cumulative loss to date since October 1 for winter-run Chinook salmon (based on length-at- date criteria) is greater than the percentage below of a loss threshold calculated as 2 percent of the juvenile production estimate:

    - January 1 – 15: 2 percent (0.04 percent of juvenile production estimate)
    - January 16 – 31: 4 percent (0.08 percent of juvenile production estimate)
    - February 1 – 14: 6 percent (0.12 percent of juvenile production estimate)
    - February 15 – 28: 9 percent (0.18 percent of juvenile production estimate)
    - March 1 – 15: 21 percent (0.42 percent of juvenile production estimate)
    - March 16 – 31: 26 percent (0.52 percent of juvenile production estimate)

    - April 1 – End of Old and Middle River: 30 percent (0.60 percent of juvenile production estimate)
  - Predicted cumulative loss for winter-run Chinook salmon is greater than 30 percent of the loss threshold described above in "Additional Real-Time Old and Middle River Restrictions" (one percent of the Winter-Run Chinook Salmon juvenile production estimate (genetically confirmed) or two percent of the Winter-Run Chinook Salmon juvenile production estimate (based on length-at-date)) or salvage for steelhead is greater than 50 percent of the salvage threshold described above in "Additional Real-Time Old and Middle River Restrictions."
  - Changes in spawning, rearing, foraging, sheltering, or migration behavior beyond those described in the forthcoming biological opinion for this project.

- End of Old and Middle River Management: Old and Middle River criteria may control operations until June 30, or when both of the following conditions have occurred, whichever is earlier:
  - Delta smelt: when the daily mean water temperature at Clifton Court Forebay reaches 25°C for 3 consecutive days.
  - Salmonids: when more than 95 percent of listed salmonids have migrated past Chipps Island, as determined by the Delta monitoring working group, OR after daily average water temperatures at Mossdale exceed 72°F for 7 days during June (the 7 days do not have to be consecutive).

8.6.9.1 Assess Species Exposure to Proposed South Delta Operations

Note: Much of the description in this section is based on an earlier version of the proposed action that subsequently changed during the consultation. A supplemental analysis based on proposed action revisions received June 14, 2019 is provided in Section 8.6.12.9. We carried the findings of the supplemental analysis into the Integration and Synthesis section of this Opinion.

The temporal and spatial occurrence of each run of Chinook salmon, CCV steelhead, and sDPS green sturgeon in the Delta is intrinsic to their natural history and summarized in Section 6: *Status of the Species and Critical Habitat*.

Old and Middle River Flows – The modeling conducted for the proposed action (February 5, 2019; (U.S. Bureau of Reclamation 2019c)) depicts that Old and Middle River flows will become more negative in April and May under the proposed action as compared to the current operating scenario. Under current operating scenario San Joaquin River flow requirements (I:E ratio) restricted export rates to a ratio of the inflow of the San Joaquin River as measured at Vernalis during April and May. Old and Middle River flow management restricted exports under current operating scenario to manage to more positive Old and Middle River flow values for specified periods of time when certain threshold triggers of listed fish loss occurred at the CVP and SWP fish salvage facilities.

In addition, the modeled Old and Middle River flow patterns depict more negative values for Old and Middle River in the months of January, February, March and June (Table 65). Furthermore, more negative Old and Middle River flows are modeled to occur in October of wet and above normal water year types with a difference of approximately 1,500 cfs under the February 5, 2019 proposed action as compared to the current operating scenario conditions. A similar response is modeled for January of above and below normal water year types in which the proposed action is approximately 700 cfs more negative than the modeled current operating scenario flows for Old and Middle River. In drier water year types, the modeling indicated that Old and Middle River flows in February and March are anticipated to be 1,000 to 1,600 cfs more negative (below normal to critical water year types) with the differences becoming greater as water year types become drier.

Table 65. Proposed action minus current operations scenario for Old and Middle River monthy average flows.

	Monthly Flow (Cubic Feet per Second)											
Statistic	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Probability of Exceedance												
10%	723	727	**-110**	**-125**	**-1,327**	168	**-3,943**	**-4,197**	**-1,246**	171	91	241
20%	483	678	72	**-1,694**	**-2,397**	**-1,813**	**-3,565**	**-3,001**	**-2,036**	1,463	**-148**	466
30%	564	815	244	**-1,161**	**-1,696**	**-929**	**-3,338**	**-2,928**	**-1,000**	713	**-483**	271
40%	521	522	581	**-168**	**-964**	**-1,016**	**-3,325**	**-3,063**	**-1,000**	50	**-117**	**-166**
50%	**-198**	**-75**	581	194	**-319**	**-499**	**-2,808**	**-2,944**	**-1,000**	236	**-213**	**-445**
60%	**-1,257**	**-520**	581	**-7**	517	369	**-2,236**	**-2,721**	**-183**	62	**-81**	180
70%	**-2,012**	**-982**	657	**-226**	108	76	**-2,230**	**-2,492**	0	**-12**	24	394
80%	**-2,067**	**-811**	2,516	**-226**	**-193**	0	**-2,110**	**-2,564**	0	**-182**	35	383
90%	**-2,090**	580	**-63**	**-226**	**-250**	0	**-2,102**	**-2,605**	0	68	**-114**	461
Long Term												
Full Simulation Period[a]	**-427**	192	468	**-348**	**-598**	**-359**	**-2,706**	**-2,767**	**-658**	232	**-150**	215
Water Year Types[b,c]												
Wet (32%)	**-1,476**	**-1,096**	314	**-295**	297	493	**-4,053**	**-3,907**	225	34	78	238
Above Normal (16%)	**-1,495**	643	1,450	**-729**	**-96**	256	**-3,865**	**-3,550**	28	**-463**	56	387
Below Normal (13%)	756	736	566	**-652**	**-1,001**	**-555**	**-2,603**	**-2,802**	**-1,593**	**-226**	**-1,016**	**-71**
Dry (24%)	338	1,034	155	**-139**	**-1,271**	**-1,124**	**-1,482**	**-1,963**	**-1,487**	1,067	**-270**	244
Critical (15%)	641	593	167	**-120**	**-1,587**	**-1,412**	**-668**	**-755**	**-1,079**	443	129	195

a Based on the 82-year simulation period.
b As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (State Water Resources Control Board 1999)
c These results are displayed with calendar year - year type sorting.
d All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.
e These are draft results meant for qualitative analysis and are subject to revision.

The shift in April and May Old and Middle River flow values between the proposed action and current operating scenario, as modeled, indicated that differences of approximately 4,000 cfs more negative flows would occur in wetter years. In drier years (below normal and dry water year types) the differences between the proposed action and current operating scenario were less, but were still approximately 1,500 cfs more negative under the proposed action conditions as compared to the current operating scenario conditions. In critical water year types, the February 5, 2019, proposed action was modeled to be 600-800 cfs more negative than the current operating scenario conditions. Seldom during the April and May period are modeled Old and Middle River flows predicted to be more positive/less negative under the proposed action than under the current operating scenario conditions, and positive Old and Middle River flow values occur in April and May less frequently under the proposed action (<10 percent of years) compared to the current operating scenario (approximately 50 percent of years). During June, the proposed action is modeled as being more negative by 1,000 to 1,600 cfs in drier water year types (below normal, dry, and critical).

In summary, the modeled Old and Middle River flow values for the proposed action indicate that for most of the winter and spring months (25 of the 30 month and water year type combinations for January through June) flows will be more negative in the channels leading to the export facilities, creating conditions that, per NMFS's conceptual model, will be more negative to fish.

Exports – In April and May, modeling indicated that combined exports would be almost twice as high for the proposed action as compared to the current operating scenario conditions (Table 66). Combined exports under the current operating scenario conditions were modeled to average 2,300 cfs in May and 2,500 cfs in April for the full simulation period. In contrast, combined exports under the proposed action were modeled to be 5,284 cfs in May and 5,564 cfs in April. Differences in the export flows during April ranged from approximately 4,500 cfs in wet years to 713 cfs in critical years, with the proposed action flows always modeled to be greater than the current operating scenario conditions. In May, a similar trend is also seen. Differences in export flows are modeled to be approximately 4,250 cfs in wet years and 761 cfs in critical years, with the proposed action always having greater export flows. Average monthly combined exports are consistently greater under the proposed action than the current operating scenario for all months except December and July. The differences between the proposed action and current operating scenario range from -548 cfs in December (current operating scenario > proposed action) to 2,977 cfs in May (PA > current operating scenario). In almost all water year types, exports modeled for the proposed action are greater than for the current operating scenario conditions in October, November, January, February, March, April, and May. In wet years, exports in the proposed action are substantially greater in October, November, April, and May. In drier years (below normal to critical water year types) the proposed action typically has flows that are 1,000 cfs or greater than the current operating scenario conditions for the January through June period.

Table 66. Proposed action minus current operations scenario for total Bay-Delta exports monthly water delivery.

	Monthly Deliveries (Cubic Feet per Second)											
Statistic	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Probability of Exceedance												
10%	3,461	32	**-35**	**-126**	**-140**	**-449**	4,529	4,571	**-521**	11	0	0
20%	3,638	1,945	**-758**	46	**-78**	**-565**	4,815	4,974	**-90**	0	0	0
30%	3,215	2,081	**-1,670**	533	15	**-359**	4,497	4,235	**-364**	144	**-20**	0
40%	2,330	1,575	**-773**	312	213	53	4,438	4,086	**-324**	**-93**	0	130
50%	1,299	1,172	**-700**	398	402	211	3,838	3,693	747	**-506**	543	1,019
60%	361	491	**-696**	308	373	318	3,062	2,836	1,296	**-415**	926	747
70%	182	**-170**	**-700**	380	729	1,145	1,707	2,211	1,401	**-783**	120	**-136**
80%	27	**-231**	**-47**	680	1,703	1,225	1,304	1,734	2,304	**-1,462**	151	**-173**
90%	**-174**	**-21**	**-118**	1,381	2,951	2,198	954	877	1,441	**-665**	32	**-105**
Long Term												
Full Simulation Period[a]	1,397	726	**-548**	393	742	404	2,971	2,977	660	**-272**	149	215
Water Year Types[b,c]												
Wet (32%)	2,688	2,341	**-474**	312	**-31**	**-502**	4,476	4,244	**-232**	**-24**	**-79**	304
Above Normal (16%)	2,645	258	**-1,579**	899	149	**-225**	4,433	3,966	**-152**	400	**-58**	144
Below Normal (13%)	99	52	**-615**	737	1,071	548	2,737	2,865	1,656	226	1,099	518
Dry (24%)	445	**-281**	**-157**	148	1,371	1,234	1549	2,069	1,544	**-1,161**	252	69
Critical (15%)	24	34	**-183**	110	1,709	1,535	713	781	1,089	**-512**	**-178**	64

a Based on the 82-year simulation period.
b As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (State Water Resources Control Board 1999)
c These results are displayed with calendar year - year type sorting.
d All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.
e These are draft results meant for qualitative analysis and are subject to revision.

Velocity Density Modeling – The results of the velocity density modeling parallel the trends already exhibited for Old and Middle River and combined export modeling. In locations along the Old and Middle river routes, density plots show a shift to more negative velocities in the March through May periods for river reaches adjacent to the export facilities. Modeling for the velocity density comparisons used 3-month bins: December through February, March through May, June through August, and September through November. The 3-month bin for the modeling obscures the details of the effects of exports and reverse flows in Old and Middle rivers on a monthly basis as was presented earlier. The shift to more negative velocity values in the March through May period for the Old River and Middle River channel segments (89, 90, and 143) indicate the hydrodynamic effects of the increased combined exports and mirrors the resulting trends seen in the Old and Middle River flow values for the modeled proposed action conditions. Greater exports would tend to create more negative Old and Middle River flows given the same inflow and tidal conditions, and given that the geometry of the channel segments used in the modeling should remain consistent, increased negative flow should result in more negative velocity values in those channels.

For example, the velocity density plots for Old River at Highway 4, and just upstream towards the export facilities (channels 89 and 90) show a shift to more negative velocities in the March through May period for all water year types. Similar trends are seen for Middle River at Woodward Island (channel 143) and Old River near Woodward Island (channel 95).

8.6.9.2 South Delta Salvage and Entrainment

Entrainment of juvenile winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon 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 fish collection facilities as they go through the salvage process, and is estimated based on the number of salvaged fish (fish observed within the fish collection facilities at the export facilities) and a number of components related to facility efficiency and handling. For example, at the SWP, the salvage process starts with fish entrainment into Clifton Court Forebay, and proceeds with fish moving across the Clifton Court Forebay until they enter the Skinner Delta Fish Protective Facility, where they are collected in holding tanks. After fish collection, a subsample is counted for determining the number of fish salvaged in a given period of time. This is usually represented by a 30-minute subsample of a two-hour block of fish collections. After this stage, fish are transferred to tanker trucks and driven to releases sites in the western Delta and released back into the Sacramento or San Joaquin rivers. At the CVP, the fish salvage process is considered to start with fish encountering the trash rack on Old River in front of the primary channel, and then progressing through the salvage process until the salvaged fish are ultimately releases at the release sites, similar to the process at the Skinner Delta Fish Protective Facility. In the following description, 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 Delta 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.

- SWP: (1) Prescreen loss (from Clifton Court Forebay radial gates to primary louvers at the Skinner Delta 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[12]: 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): 64.9 percent.

For purposes of evaluating the effect of near-field south Delta exports on Chinook salmon, steelhead, and green sturgeon, NMFS presents juvenile loss data using: (1) historical salvage and loss data; and (2) salvage-density method as modeled.

NMFS provides a quantitative analyses of entrainment differences between current operating scenario and proposed action using the salvage density methodology, and a qualitative discussion of potential predation differences between current operating scenario and proposed action. The salvage-density method (Appendix C) relies on historic export rates and observed loss of salmonids and sturgeon at the CVP and SWP collection facilities (for water years 1995-2009). This period represents a hydrologic regime that predates the 2009 Biological Opinion and does not reflect the -5,000 Old and Middle River restriction (or other operations) in either the proposed action or current operating scenario. This period was what was used in the equivalent modeling for the California WaterFix consultation and the accelerated timeframe of the current consultation didn’t allow for the method to be updated to include more recent years. The method essentially functions as a description of changes in export flows weighted by seasonal changes in loss. While the model is designed as a comparative tool, NMFS does use the absolute estimates of loss to put the potential effect into a population context for CV spring-run Chinook salmon and CCV steelhead, but those results should be considered a coarse screening level analysis due to limitations of the salvage-density method itself (limited historical time-frame of loss; relatively simple weighting of loss by export changes and no other operational factors) and use of the average annual modeled loss rates (over the 15-year data period) scaled to both low and high population estimates. Since it is likely that annual observed loss in a particular year is correlated with population size, use of the average loss rate likely overestimates the population effect in a low-population year, and underestimates the population effect in a high-population year.

8.6.9.2.1 Sacramento River Winter-run Chinook salmon exposure

Fish entrained at the state and Federal fish collection facilities that reach the salvage tanks are collected and transported back to the Delta from both the state and Federal water projects. A screened subsample of fish that reach the salvage tanks are sampled every two hours and the total fish salvage per each sampling period is calculated by expanding the number of fish salvaged by the fraction of time that diversions were sampled. Fish loss for that period of time is calculated based on the standard loss equations (California Department of Water Resources 2013). Daily salvage and loss is the cumulative sum for those metrics for all of the sampling periods that occurred in that given day. Historical salvage and loss data analysis is presented in Table 67 and

[12] Note that louver efficiency does not include the loss associated with louver cleaning.

Table 68 to provide context for the loss estimates for the proposed action and current operating scenario based on the salvage density method.

Table 67. Average annual adipose fin-clipped Sacramento River winter-run-sized Chinook salmon juvenile salvage and loss from brood year 1999 to 2017.

Brood Year	Total Fish Salvage	Total Fish Loss	# Juveniles Released	Loss/Release
1999	987	2,482	153,908	1.61 %
2000	965	3,295	30,840	10.68 %
2001	2,259	6,734	166,206	4.05 %
2002	7,751	22,748	252,684	9.00 %
2003	6,094	19,319	233,613	8.27 %
2004	1,103	3,964	218,617	1.81%
2005	477	1,251	168,261	0.74%
2006	1,353	2,034	173,344	1.17%
2007	2,919	5,618	196,288	2.86%
2008	179	435	71,883	0.61%
2009	1,230	2,356	146,211	1.61%
2010	463	1,449	198,582	0.73%
2011	460	1,210	123,859	0.98%
2012	187	595	194264	0.31%
2013	6	12	181857	0.01%
2014	62	214	193155	0.11%
2015	213	628	420006	0.15%
2016	368	1,010	141388	0.71%
2017	48	183	431,793	0.04%
Mean	**1,428**	**3,976**	**194,566**	**2.39%**
Median	**477**	**1,449**	**181,857**	**0.98%**
SD	**2,101**	**6,311**	**96,720**	**3.27%**
95 percent CI	**1,013**	**3,042**	**46,618**	**1.58%**

Note: Because the number of juveniles released are known genetic winter-run Chinook salmon, but some winter-run-sized fin-clipped Chinook salmon are not genetic winter run, this table overestimates the loss as a percent of release.

Table 68. Unclipped (natural origin) annual winter-run Chinook salmon juvenile salvage and loss from brood year 1999 to 2017.

Brood Year	Total Fish Salvage	Total Fish Loss	juvenile production estimate	Loss/juvenile production estimate
1992	1,053	4,003	246,157	1.6%
1993	1,337	2,769	90,546	3.06%
1994	1,416	4,582	74,491	6.15%

Brood Year	Total Fish Salvage	Total Fish Loss	juvenile production estimate	Loss/juvenile production estimate
1995	781	2,376	338,107	0.70%
1996	397	630	165,069	0.38%
1997	726	1,525	138,316	1.10%
1998	1,514	3,715	454,792	0.82%
1999	1,936	5,828	289,724	2.01%
2000	5,932	20,062	370,221	5.42%
2001	1,442	3,331	1,864,802	0.18%
2002	2,277	6,816	2,136,747	0.32%
2003	2,728	7,779	1,896,649	0.41%
2004	469	1,373	881,719	0.16%
2005	1,008	2,601	3,831,286	0.07%
2006	2,764	3,297	3,739,069	0.09%
2007	660	1,292	589,911	0.22%
2008	582	1,515	617,783	0.25%
2009	1,064	1,656	1,179,633	0.14%
2010	1,703	4,360	332,012	1.31%
2011	841	2,079	162,051	1.28%
2012	271	732	532,809	0.14%
2013	192	322	1,196,387	0.03%
2014	53	106	124,521	0.09%
2015	36	56	101,716	0.06%
2016	46	111	166,189	0.07%
2017	114	301	201,409	0.15%
Mean	**1,205**	**3,201**	**835,466**	**1.01%**
Median	**925**	**2,228**	**354,164**	**0.28%**
SD	**1,247**	**4,027**	**1,051,836**	**1.59%**
95 percent CI	**504**	**1,626**	**424,846**	**0.64%**

Using the current methodology for calculating salvage and loss, based on expansion of observed salvaged fish and using the current loss multipliers, the average annual adipose fin clipped juvenile winter-run Chinook salmon (hatchery-produced fish) salvage and loss from brood years 1999 to 2017 were estimated to be 1,428 and 3,976 juveniles, respectively Table 69). The average proportional loss, which is the annual total loss of clipped juvenile winter-run Chinook salmon divided by the annual number of hatchery-reared and released juvenile winter-run

Chinook salmon, was 2.39 percent (Table 67). The average between 1999 and 2008 was 4.08 percent while the average from 2009-2017 was 0.52 percent.

Using the current methodology for calculating salvage and loss, based on expansion of observed salvaged fish and using the current loss multipliers, the average annual unclipped juvenile winter-run sized Chinook salmon salvage and loss from brood years 1992 to 2017 were estimated to be 1,205 and 3,201 juveniles, respectively (Table 68). The average proportional loss of unclipped juveniles, which is the annual total loss of unclipped juveniles divided by the annual juvenile production estimate (juvenile production estimate) of juvenile winter-run Chinook salmon, was 1.01 percent (Table 68). The average between 1992 and 2008 was 1.35 percent while the average from 2009-2017 was 0.36 percent.

8.6.9.2.2 Juvenile Salvage Estimates using the Salvage-Density Method

The salvage density method relies on historic exports and observed loss (for water years 1995 to 2009) of salmonids at the CVP and SWP fish salvage facilities and essentially functions as a description of changes in export flows weighted by seasonal changes in loss. The results of the salvage-density method showed that, based on modeled south Delta exports, annual loss of winter-run Chinook salmon at the south Delta export facilities would be seven percent (in Above Normal water year types) to 38 percent (in Critical water year types) higher under the proposed action than the current operating scenario (Table 69). The monthly loss of winter-run Chinook salmon at the south Delta export facilities (Table 70) shows that while loss does increase by a high percentage in April and May, the historical pattern is that the majority of winter-run Chinook salmon salvage occurs before April. Revised loss thresholds in the June 14, 2019 proposed action are expected to limit loss to be more comparable to the current operating scenario scenario. There is a specific loss threshold for winter-run Chinook salmon from December through March.

Table 69. Estimated annual loss of Sacramento River winter-run Chinook salmon at the export facilities by water year type based on the salvage-density method.

Water Year Type	Loss Under Current Operating Scenario	Loss Under Proposed Action	Proposed Action minus Current Operating Scenario	Change
Wet	12,417	13,788	1,371	11%
Above Normal	6,369	6,805	437	7%
Below Normal	5,830	6,812	982	17%
Dry	4,106	5,070	965	23%
Critical	1,230	1,702	472	38%

Table 70. Estimated annual loss of Sacramento River winter-run Chinook salmon at the export facilities by month for all water year types based on the salvage-density method.

Water Year Type	Loss Under Current Operating Scenario	Loss Under Proposed Action	Proposed Action minus Current Operating Scenario	Change
October	0	0	0	--
November	0	0	0	--
December	518	459	-59	-11
January	2,807	2,987	180	6
February	903	922	19	2
March	7,141	6,703	-438	-6
April	1,046	2,713	1,667	159
May	2	4	2	135
June	0	0	0	--
July	0	0	0	--
August	0	0	0	--
September	0	0	0	--

The absolute differences between the proposed action and the current operating scenario were greater in wetter water years, as a result of more south Delta export pumping, however a greater percentage difference between the estimated loss occurred in drier water year types (Table 71). For winter-run Chinook salmon, the differences ranged from 5.3 percent more under the proposed action at the SWP in above normal years to 45.3 percent more under the proposed action at the CVP in critical years (Table 71). Within years, the monthly estimated loss varied considerably. The estimated loss rates were typically higher from January through May for all water year types for the proposed action compared to the current operating scenario. However, February and March had lower loss values in wet years for the proposed action compared to the current operating scenario conditions, but higher values in drier years (Table 72, Table 73, Table 74, Table 75, and Table 76). The largest percentile differences between the proposed action and current operating scenario occurred in April, where the modeled proposed action loss could be as much as 238 percent more than the current operating scenario loss (above normal years at the SWP, Table 73) and loss values were typically 100 percent higher for the other water year types. This difference reflects the increase in exports during April under the proposed action compared to the current operating scenario conditions. Revised loss thresholds during consultation are expected to limit loss to be more comparable to the current operating scenario scenario.

Table 71. Estimated number juvenile Sacramento River winter-run Chinook salmon lost annually due to entrainment at the export facilities by water year type.

Water Year Type	State Water Project			Central Valley Project		
	current operating scenario	PA	PA – current operating scenario (percent change)	current operating scenario	PA	PA v current operating scenario (percent change)
Wet	10,961	12,235	1,275 (11.6%)	1,456	1,553	97 (6.7%)
Above Normal	5,613	5,911	298 (5.3%)	756	895	139 (18.4%)
Below Normal	4,807	5,717	910 (18.9%)	1,024	1,095	71 (7.0%)
Dry	3,146	3,938	791 (25.1%)	959	1,133	173 (18.1%)
Critical	837	1,130	294 (35.1%)	394	572	178 (45.3%)

Table 72. Estimated number juvenile Sacramento River winter-run Chinook salmon lost due to entrainment at the export facilities in wet water years.

Month	State Water Project			Central Valley Project		
	current operating scenario	PA	PA – current operating scenario (percent change)	current operating scenario	PA	PA v current operating scenario (percent change)
October	0	0	0	0	0	0
November	0	0	0	0	0	0
December	412	361	-51 (-12.4%)	106	98	-7 (-7.0%)
January	2,641	2,821	180 (6.8%)	166	166	0 (0.1%)
February	701	734	33 (4.7%)	202	188	-14 (-7.1%)

Month	State Water Project			Central Valley Project		
	current operating scenario	PA	PA – current operating scenario (percent change)	current operating scenario	PA	PA v current operating scenario (percent change)
March	6,295	5,877	-418 (-6.6%)	846	826	-20 (-2.4%
April	910	2,439	1,529 (168 %)	136	274	139 (102.3%)
May	2	4	2 (135%)	0	0	0
June	0	0	0	0	0	0
July	0	0	0	0	0	0
August	0	0	0	0	0	0
September	0	0	0	0	0	0
Annual Average	**10,961**	**12,235**	**1,275 (11.6%)**	**1,456**	**1,553**	**97 (6.7%)**

Table 73. Estimated number juvenile Sacramento River winter-run Chinook salmon lost due to entrainment at the export facilities in above normal water years.

Month	State Water Project			Central Valley Project		
	current operatin g scenario	PA	PA – current operating scenario (percent change)	current operating scenario	PA	PA v current operating scenario (percent change)
October	0	0	0	0	0	0
November	0	0	0	0	0	0
December	359	359	0 (0.1%)	20	20	0
January	682	816	134 (19.7%)	66	71	6 (8.5%)
February	2,558	2,633	76 (3.0%)	239	241	2 (0.9%)

Month	State Water Project			Central Valley Project		
	current operating scenario	PA	PA – current operating scenario (percent change)	current operating scenario	PA	PA v current operating scenario (percent change)
March	1,940	1,850	-91 (-4.7%)	355	352	-3 (-0.8%)
April	75	253	178 (238.2%)	70	196	125 (178.1%)
May	0	0	0	4	13	9 (228.7%)
June	0	0	0	1	1	0
July	0	0	0	0	0	0
August	0	0	0	0	0	0
September	0	0	0	0	0	0
Annual Average	**5,613**	**5,911**	**298 (5.3%)**	**756**	**895**	**139 (18.4%)**

Table 74. Estimated number juvenile Sacramento River winter-run Chinook salmon lost due to entrainment at the export facilities in below normal water years.

Month -	State Water Project			Central Valley Project		
	current operating scenario	PA	PA – current operating scenario (percent change)	current operating scenario	PA	PA v current operating scenario (percent change)
October	0	0	0	0	0	0
November	0	0	0	0	0	0
December	110	100	-10 (-9.0%)	46	42	-4 (-7.8%)
January	328	383	55 (16.7%)	101	109	8 (8.3%)

Month -	State Water Project			Central Valley Project		
	current operating scenario	PA	PA – current operating scenario (percent change)	current operating scenario	PA	PA v current operating scenario (percent change)
February	1,677	2,020	343 (20.5%)	410	466	55 (13.5%)
March	2,630	3,042	412 (15.7%)	467	478	11 (2.4%)
April	21	54	33 (155.8%)	0	0	0
May	41	118	77 (188.7%)	0	0	0
June	0	0	0	0	0	0
July	0	0	0	0	0	0
August	0	0	0	0	0	0
September	0	0	0	0	0	0
Annual Average	**4,807**	**5,717**	**910 (18.9%)**	**1,024**	**1,095**	**71 (7.0%)**

Table 75. Estimated number juvenile Sacramento River winter-run Chinook salmon lost due to entrainment at the export facilities in dry water years.

Month	State Water Project			Central Valley Project		
	current operating scenario	PA	PA – current operating scenario (percent change)	current operating scenario	PA	PA v current operating scenario (percent change)
October	0	0	0	0	0	0
November	0	0	0	0	0	0
December	227	228	1 (0.5%)	37	34	-3 (-9.0%)
January	125	130	5 (4.1%)	78	79	1 (1.0%)

Month	State Water Project			Central Valley Project		
	current operating scenario	PA	PA – current operating scenario (percent change)	current operating scenario	PA	PA v current operating scenario (percent change)
February	726	867	141 (19.4%)	286	364	78 (27.4%)
March	1,974	2,539	565 (28.6%)	514	595	80 (15.6%)
April	95	174	79 (83.2%)	44	61	17 (39.8%)
May	0	0	0	0	0	0
June	0	0	0	0	0	0
July	0	0	0	0	0	0
August	0	0	0	0	0	0
September	0	0	0	0	0	0
Annual Average	**3,146**	**3,938**	**791 (25.1%)**	**959**	**1,133**	**173 (18.1%)**

Table 76. Estimated number juvenile Sacramento River winter-run Chinook salmon lost due to entrainment at the export facilities in critical water years.

Month	**State Water Project**			**Central Valley Project**		
	Current Operating Scenario (COS)	**Proposed Action (PA)**	**PA minus COS (percent change)**	**Current Operating Scenario (COS)**	**Proposed Action (PA)**	**PA minus COS (percent change)**
October	0	0	0	0	0	0
November	0	0	0	0	0	0
December	0	0	0	0	0	0
January	145	147	2 (1.6%)	45	46	1 (2.0%)
February	222	300	78 (35.0%)	115	164	48 (41.8%)
March	447	641	194 (43.4%)	229	357	128 (56.1%)
April	22	42	19 (86.1%)	4	5	1 (17.2%)
May	0	0	0	0	0	0
June	0	0	0	0	0	0
July	0	0	0	0	0	0

Month	State Water Project			Central Valley Project		
	Current Operating Scenario (COS)	Proposed Action (PA)	PA minus COS (percent change)	Current Operating Scenario (COS)	Proposed Action (PA)	PA minus COS (percent change)
August	0	0	0	0	0	0
September	0	0	0	0	0	0
Annual Average	**837**	**1,130**	**294 (35.1%)**	**394**	**572**	**178 (45.3%)**

Increased entrainment into the south Delta fish collection facilities would decrease migratory success for winter-run Chinook salmon that are exposed to the export facilities in the waterways immediately adjacent to the facility intakes and that do not migrate through the salvage facilities. An increased negative flow in the region immediately adjacent to the intakes to the Clifton Court Forebay and the CVP would increase the probability of fish being unable to reverse course and successfully exit the Delta, although the magnitude of this effect is currently unknown due to a lack of data regarding fine scale, reach specific fish movement behavior and survival in those reaches under increased export conditions. Increased pumping has far-field migratory impacts as well, particularly in the Old and Middle River corridors which would negatively affect winter-run Chinook salmon in those corridors. Fish that are present in the Old River or Middle River corridors and their distributaries downstream of the south Delta export facilities would experience increased net flows towards the export facilities. Increased exports would obscure more of the ebbing tide signal that would normally cue fish to move out of those corridors and back into the main migratory corridor of the San Joaquin River before moving southwards into waters that are more heavily influenced by the effects of reverse flows due to exports.

It is possible that some of the loss modeled to occur at the export facilities under the proposed action flow conditions might have occurred due to far-field effects in the south Delta under current operating scenario conditions, but no modeling tool is available that allows estimation of and comparison of independent estimates of direct loss and far-field effects under the proposed action vs. current operating scenario. Fish that may have been predated upon or otherwise lost in far field areas under the influence of the Project operations in the current operating scenario scenario (i.e., migrational delay, increased transit time, increased predator exposure) may arrive at the fish salvage facilities under the proposed action scenario due to faster transit times in the adjacent river routes, thus having less exposure to predators, only to be lost in the salvage process at the fish facilities. While we do have information on reach-scale survivals and travel-times, our current understanding of subdaily, fine scale fish movement within a reach (and associated survival outcomes) is limited since no study has deployed sufficient instrumentation to track fine scale movement and fish survival outcomes. Tools such as the Delta Passage Model provide estimates of total through-Delta survival.

An important concept to note is that even though the numbers of fish lost in the drier water year types may be lower than during wetter water year types, this is a function of overall watershed survival differences between water year types. During wet water years, more juvenile salmonids enter the south Delta from either basin and greater numbers are therefore exposed to the export facilities (Brandes and McLain 2001; Kjelson et al. 1982; Newman and Brandes 2010). Lower numbers of fish salvaged in drier years, therefore, does not necessarily indicate that restrictions on pumping are impacting a smaller proportion of fish. Often the Old and Middle River flows are more negative in dry years even if exports are reduced. In dry years, less water is flowing into the Delta from tributaries, and in particular the San Joaquin River basin. Less flow into the Head of Old River will exacerbate the effects of exports since there is less flow moving downstream from the Head of Old River towards the CVP and SWP intakes to offset the volume of water being diverted, and more water will have to come from alternative sources, such as the waters of the central Delta to supply the volume of water being exported. Conversely, it is possible to be exporting to full capacity in the wet years and Old and Middle River flows are still positive due to very high San Joaquin River and tributary flows, which can completely offset the volume of water being diverted by the CVP and SWP.

8.6.9.2.3 Central Valley Spring-Run Chinook Salmon Exposure

Using the current methodology for calculating salvage and loss, based on expansion of observed salvaged fish and using the current loss multipliers, the estimate of average annual adipose fin clipped CV spring-run Chinook salmon juvenile salvage and loss from brood year 1999 to 2017 were 667 and 1,406 juveniles (Table 77), respectively, for the SWP and CVP combined. The estimated average proportional loss, which is the estimated annual total loss divided by the annual number of hatchery-reared and released CV spring-run Chinook salmon juveniles, was 0.63 percent (Table 77).

The estimated cumulative SWP and CVP average annual unclipped CV spring-run sized Chinook salmon juvenile salvage and loss from brood year 1992 to 2017 using the current methodology for calculating salvage and loss, based on expansion of observed salvaged fish and using the current loss multipliers, were 14,062 and 26,241 juveniles (Table 77), respectively.

Table 77. Average annual adipose fin-clipped Central Valley spring-run Chinook salmon juvenile salvage and loss from brood year 1999 to 2017.

Brood Year	Total Fish Salvage	Total Fish Loss	# Juvenile Released	Loss/Release
1999	2,226.00	8,657.00	171,340.00	5.0525%
2000	270.00	726.00	No Data	No Data
2001	2,754.00	4,373.00	254,591.00	1.7177%
2002	864.00	2,520.00	128,200.00	1.9657%
2003	205.00	586.00	No Data	No Data
2004	2,488.00	3,633.00	561,920.00	0.6465%
2005	601.00	632.00	No Data	No Data
2006	31.00	44.00	5,219,080.00	0.0008%
2007	107.00	251.00	214,159.00	0.1172%
2008	15.00	11.00	108,085.00	0.0102%
2009	42.00	73.00	51,762.00	0.1410%
2010	276.00	793.00	3,258,949.00	0.0243%
2011	142.00	289.00	2,314,266.00	0.0125%
2012	7.00	15.00	92,396.00	0.0162%
2013	12.00	8.00	2,997,011.00	0.0003%
2014	8.00	7.00	2,090,391.00	0.0003%
2015	650.00	560.00	2,127,482.00	0.0263%
2016	962.70	1,787.00	1,788,310.00	0.0999%
2017	1,010.00	1,745.27	663,434.00	0.2631%
Average	**667**	**1,406**	**1,377,586**	**0.6309%**
Median	270	586	612,677	0.0631%
SD	881	2,169	1,524,528	1.3293%

Brood Year	Total Fish Salvage	Total Fish Loss	# Juvenile Released	Loss/Release
95 percent CI	425	1,045	734,799	0.6407%

Table 78. Unclipped (natural origin) annual Central Valley spring-run Chinook salmon juvenile salvage and loss from brood year 1999 to 2017.

Brood Year	Total Fish Salvage	Total Fish Loss	Brood Year	Total Fish Salvage	Total Fish Loss
1992	7,721	13,265	2005	5,822	13,002
1993	3,555	3,785	2006	3,378	5,213
1994	24,200	29,905	2007	5,100	11,771
1995	26,785	36,851	2008	4,730	8,840
1996	42,908	54,855	2009	4,068	6,082
1997	30,597	24,943	2010	17,654	52,505
1998	46,655	105,615	2011	1,063	2,394
1999	42,513	90,118	2012	909	2,496
2000	17,940	40,696	2013	484	349
2001	8,177	10,206	2014	50	70
2002	15,706	40,383	2015	158	298
2003	4,534	10,985	2016	26,713	72,013
2004	14,694	27,319	2017	9,487	18,314
			Mean	**14,062**	**26,241**
			Median	**7,949**	**13,134**
			SD	**14,276**	**28,597**
			95 percent CI	**5,766**	**11,550**

8.6.9.2.4 Juvenile Salvage Estimates for Spring-run Chinook Salmon using the Salvage-Density Method

The salvage density method relies on historic exports and observed loss (for water years 1995-2009) of salmonids at the CVP and SWP fish salvage facilities and essentially functions as a description of changes in export flows weighted by seasonal changes in loss (see caveats in Section 2.4.4: *Assumptions in the Analysis*). The historical loss pattern used in the Salvage-Density modeling identified fish to run based on length-at-date criteria. Because of run-assignment errors associated with the length-at-date criteria, much of projected spring-run-sized loss may not represent genetic CV spring-run Chinook salmon loss, but rather represent loss of (primarily) unmarked hatchery fall-run. Harvey and Stroble (2013) reported that 98 percent of the spring-run-sized fish in their sample were not genetic spring-run (95 percent genetic fall-run, one percent genetic winter-run, and two percent genetic late-fall-run). In order to generate a loss estimate more representative of genetic CV spring-run Chinook salmon, we multiplied the projected loss numbers by 0.02 and refer to the outcome as “adjusted loss.”

The results of the salvage-density method showed that, based on modeled south Delta exports, annual adjusted loss of CV spring-run Chinook salmon at the south Delta export facilities would be 64 percent (in Critical years) to 159 percent (in Above Normal years) higher under the proposed action than the current operating scenario (Table 79).

Table 79. Estimated annual adjusted loss of Central Valley spring-run Chinook salmon at the export facilities by water year type based on the salvage-density method.

Water Year Type	Loss under Current Operating Scenario (COS)	Loss under Proposed Action (PA)	PA minus COS	Change
Wet	851	1,732	881	104%
Above Normal	461	1,193	732	159%
Below Normal	116	234	117	101%
Dry	278	482	205	74%
Critical	153	249	97	64%

NMFS put the combined CV spring-run Chinook salmon loss in a population context by expressing the estimated annual combined loss as a percentage of the juvenile CV spring-run Chinook salmon entering the Delta. These results should be considered a coarse screening level analysis due to limitations of the salvage-density method itself (limited historical time-frame of loss; relatively simple weighting of loss by export changes and no other operational factors) and use of the average annual modeled loss rates (over the 15-year data period) scaled to both low and high population estimates. Since it is likely that annual observed loss in a particular year is correlated with population size, use of the average loss rate likely overestimates the population effect in a low-population year, and underestimates the population effect in a high-population year.

Assuming that the relationship between spring-run escapement and number of juveniles entering the Delta is similar to that for winter-run Chinook salmon[13] (Table 80), the observed Brood Year 2010 to 2018 tributary CV spring-run Chinook salmon escapement range of 1,059 to 19,516 is estimated to produce 35,334 to 3,837,720 juvenile CV spring-run Chinook salmon entering the Delta. The estimated annual combined loss from the current operating scenario is 851 juveniles, and estimated annual combined loss from the proposed action is 1,732. Applying the estimated annual combined loss to the lowest and highest juvenile population estimates provides ranges of <1 (851 ÷ 3,837,720) to 2 (851 ÷ 35,334) percent loss of the juvenile CV spring-run Chinook salmon population in the Delta for the current operating scenario, and <1 (1,732 ÷ 3,837,720) to 5 (1,732 ÷ 35,334) percent loss of the juvenile CV spring-run Chinook salmon population in the Delta for the proposed action. Since it is likely that annual observed loss in a particular year is correlated with population size, use of the average loss rate likely overestimates the population

[13] Mortality during spawning, egg incubation, and juvenile rearing and migration may differ between spring-run and winter-run Chinook salmon since the seasonal timing of those life history stages don't fully overlap, but we used this assumption since winter-run Chinook salmon is the only salmonid for which there is an estimate of juveniles entering the Delta.

effect in a low-population year, and underestimates the population effect in a high-population year.

Table 80. Sacramento River winter-run Chinook salmon juvenile production and estimated Central Valley spring-run Chinook salmon juvenile production by year.

		Sacramento River Winter-run			Central Valley Spring-run	
Water Year	Brood Year	Adult Escapement	Juvenile Production Estimate (JPE)	Multiplier JPE/ Escapement	Sacramento River Tributary Escapement	Estimated JPE (Escapement times multiplier)
2010	2009	4,537	1,179,633	260	3,457	898,830
2011	2010	1,596	3,32,012	208	2,962	616,178
2012	2011	827	162,051	196	5,805	1,137,492
2013	2012	2,671	532,809	199	18,688	3,727,868
2014	2013	6,084	1,196,387	197	19,516	3,837,720
2015	2014	3,015	124,521	41	7,125	2,94,266
2016	2015	3,440	101,716	30	1,195	35,334
2017	2016	1,547	166,189	107	6,453	693,224
2018	2017	977	201,409	206	1,059	218,313

The results of the salvage-density method showed that, based on modeled south Delta exports, mean loss at the south Delta export facilities would be substantially higher under the proposed action than the current operating scenario in all water year types for CV spring-run Chinook salmon. The absolute differences and percentile differences between the proposed action and the current operating scenario were greater in wetter water years, as a result of more south Delta export pumping (Table 81). For CV spring-run Chinook salmon, the differences ranged from 28.2 percent more under the proposed action at the CVP in critical years to 167.5 percent more under the proposed action at the SWP in above normal years (Table 81). Within years, the monthly estimated loss varied considerably. The estimated loss rates were typically higher from March through May for drier year types for the proposed action compared to the current operating scenario. However, March had lower loss values in wet years for the proposed action compared to the current operating scenario conditions, but higher values in drier years (Table 82, Table 83, Table 84, Table 85, and Table 86). The largest percentile differences between the proposed action and current operating scenario occurred in April, where the proposed action loss rate could be as much as 238 percent higher than the current operating scenario conditions in above normal years (Table 83) and loss values were typically 80 percent higher for the other water year types. This difference reflects the substantial increase in exports during April under the proposed action compared to the current operating scenario conditions.

Table 81. Estimated number juvenile Central Valley spring-run Chinook salmon lost due to entrainment at the export facilities by type of water year.

Water Year Type	-	-	State Water Project	-	-	Central Valley Project
--	current operating scenario	PA	PA – current operating scenario (percent change)	current operating scenario	PA	PA v current operating scenario (percent change)
Wet	26,589	58,046	31,457 (118%)	15,943	28,560	12,617 (79.1%)
Above Normal	16,286	43,560	27,273 (167.5%)	6,770	16,100	9,329 (137.8%)
Below Normal	4,632	9,819	5,187 (112.0%)	1,183	1,860	677 (57.3%)
Dry	10,659	19,692	9,034 (84.8%)	3,226	4,426	1,200 (37.2%)
Critical	5,131	9,272	4,141 (80.7%)	2,497	3,201	705 (28.2%)

Table 82. Estimated number juvenile Central Valley spring-run Chinook salmon lost due to entrainment at the export facilities in wet water years.

Month	-	-	State Water Project	-	-	Central Valley Project
--	current operating scenario	PA	PA – current operating scenario (percent change)	current operating scenario	PA	PA v current operating scenario (percent change)
October	7	10	3 (48.5%)	0	0	0
November	0	0	0	0	0	0
December	0	0	0	0	0	0
January	0	0	0	0	0	0
February	198	208	9 (4.7%)	29	27	-2 (-7.1%)
March	5,761	5,378	-382 (-6.6%)	3,766	3,676	-90 (-2.4%)
April	13,515	36,218	22,703 (168.0%)	8,353	16,897	8,544 (102.3%)
May	6,755	15,874	9,120 (135.0%)	3,620	7,797	4,177 (115.4%)
June	354	357	4 (1.0%)	175	163	-12 (-6.7%)
July	0	0	0	0	0	0
August	0	0	0	0	0	0
September	0	0	0	0	0	0
Annual Average	26,589	58,046	31,457 (118.3%)	15,943	28,560	12,617 (79.1%)

Table 83. Estimated number juvenile Central Valley spring-run Chinook salmon lost due to entrainment at the export facilities in above normal water years.

Month	-	-	State Water Project	-	-	Central Valley Project
--	current operating scenario	PA	PA – current operating scenario (percent change)	current operating scenario	PA	PA v current operating scenario (percent change)
October	0	0	0	0	0	0
November	0	0	0	0	0	0
December	0	0	0	0	0	0
January	4	5	1 (19.7%)	6	7	1 (8.5%)
February	56	57	2 (3.0%)	18	18	0 (0.9%)
March	4,610	4,395	-215 (-4.7%)	1,663	1,649	-14 (-0.8%)
April	9,774	33,057	23,283 (238.2%)	4,442	12,353	7,911 (178.1%)
May	1,778	5,974	4,196 (236.0%)	627	2,061	1,434 (228.7%)
June	55	62	7 (13.0%)	14	13	-2 (-10.8%)
July	0	0	0	0	0	0
August	0	0	0	0	0	0
September	9	9	0	0	0	0
Annual Average	16,286	43,560	27,273 (167.5%)	6,770	16,100	9,329 (137.8%)

Table 84 Estimated number juvenile Central Valley spring-run Chinook salmon lost due to entrainment at the export facilities in below normal water years.

Month	-	-	State Water Project	-	-	Central Valley Project
---	current operating scenario	PA	PA – current operating scenario (percent change)	current operating scenario	PA	PA v current operating scenario (percent change)
October	0	0	0	0	0	0
November	0	0	0	0	0	0
December	0	0	0	0	0	0
January	9	11	2 (16.7%)	0	0	0
February	22	27	5 (20.5%)	0	0	0
March	1,561	1,806	245 (15.7%)	577	591	14 (2.4%)
April	2,431	6,219	3,788 (155.8%)	480	933	453 (94.4%)
May	608	1,756	1,148 (188.7%)	126	336	210 (167.0%)
June	0	0	0	0	0	0

Month	-	-	State Water Project	-	-	Central Valley Project
July	0	0	0	0	0	0
August	0	0	0	0	0	0
September	0	0	0	0	0	0
Annual Average	4,632	9,819	5,187 (112.0%)	1,183	1,860	677 (57.3%)

Table 85. Estimated number juvenile Central Valley spring-run Chinook salmon lost due to entrainment at the export facilities in dry water years.

Month	-	-	State Water Project	-	-	Central Valley Project
--	current operating scenario	PA	PA – current operating scenario (percent change)	current operating scenario	PA	PA v current operating scenario (percent change)
October	0	0	0	0	0	0
November	0	0	0	0	0	0
December	0	0	0	0	0	0
January	0	0	0	6	6	0
February	0	0	0	2	3	1 (27.4%)
March	1,084	1,394	310 (28.6%)	591	683	92 (15.6%)
April	6,600	12,089	5,489 (83.2%)	2,510	3,509	999 (39.8%)
May	2,975	6,210	3,235 (108.7%)	112	218	106 (94.5%)
June	0	0	0	4	6	2 (39.8%)
July	0	0	0	0	0	0
August	0	0	0	0	0	0
September	0	0	0	0	0	0
Annual Average	10,659	19,692	9,034 (84.8%)	3,226	4,426	1,200 (37.2%)

Table 86. Estimated number juvenile Central Valley spring-run Chinook salmon lost due to entrainment at the export facilities in critical water years.

Month	-	-	State Water Project	-	-	Central Valley Project
--	current operating scenario	PA	PA – current operating scenario (percent change)	current operating scenario	PA	PA v current operating scenario (percent change)
October	0	0	0	0	0	0
November	0	0	0	0	0	0
December	0	0	0	0	0	0

Month	-	-	State Water Project	-	-	Central Valley Project
January	0	0	0	0	0	0
February	0	0	0	0	0	0
March	138	198	60 (43.4%)	95	148	53 (56.1%)
April	2,736	5,092	2,356 (86.1%)	1,345	1,577	232 (17.2%)
May	2,240	3,909	1,669 (74.5%)	1,054	1,471	418 (39.6%)
June	17	73	56 (319.6%)	3	6	2 (67.8%)
July	0	0	0	0	0	0
August	0	0	0	0	0	0
September	0	0	0	0	0	0
Annual Average	5,131	9,272	4,141 (80.7%)	2,497	3,201	705 (28.2%)

Table 87. Annual adipose fin-clipped juvenile California Central Valley steelhead salvage and loss from brood years 1999 to 2017.

Brood Year	Total Fish Salvage	Total Fish Loss	# Juvenile Released	Loss/Release
1999	181	367	1476342	0.02%
2000	5432	7950	1398412	0.57%
2001	8191	15723	1633825	0.96%
2002	1885	3345	1496220	0.22%
2003	10388	28222	1523646	1.85%
2004	7976	20917	1434217	1.46%
2005	2046	4148	1963911	0.21%
2006	2169	8110	1644777	0.49%
2007	2853	10052	1915192	0.52%
2008	2836	7548	2085566	0.36%
2009	994	2489	1391770	0.18%
2010	3576	11272	1470438	0.77%
2011	721	1214	1234235	0.10%
2012	593	1829	1556276	0.12%
2013	701	1588	1583302	0.10%
2014	523	1841	1869101	0.04%
2015	1322	3567	-*	-*
2016	43	164	-*	-*
2017	732	2463	-*	-*

Brood Year	Total Fish Salvage	Total Fish Loss	# Juvenile Released	Loss/Release
Mean	2,798	6,990	1,604,827	0.50%
Median	1,885	3,567	1,539,961	0.29%
SD	3,034	7,569	236,485	0.53%
95 percent CI	1,463	3,648	113,982	0.26%

**Data were not available, therefore, the percent loss could not be calculated.*

As discussed previously for winter-run Chinook salmon juveniles, there are many issues that influence the movement and vulnerability of juvenile CV spring-run Chinook salmon to entrainment, salvage, and loss at the fish collection facilities for the CVP and SWP. Like winter-run Chinook salmon, the majority of CV spring-run Chinook salmon originate in the Sacramento River basin and, thus, follow a common emigration pathway to the Delta through the main stem of the Sacramento River. Factors which influence the routing and survival of winter-run Chinook salmon juveniles will also influence the routing and survival of juvenile CV spring-run Chinook salmon. A further issue, that does not apply to juvenile winter-run Chinook salmon is the emigration of juvenile CV spring-run Chinook salmon out of the San Joaquin River basin (originating from the experimental population) and the necessity of surmounting obstacles unique to the San Joaquin River basin, including the actions of the south delta agricultural barriers, and migrating through the waterways of the south Delta as the primary route to the ocean and not as a secondary route as seen for the Sacramento River basin fish.

Increased entrainment into the south Delta facilities is expected to decrease migratory success for CV spring-run Chinook salmon that are exposed to the pumping plants in the waterways immediately adjacent to the facility intakes. A more negative flow environment in the region immediately adjacent to the intakes of the Clifton Court Forebay and the CVP would decrease the probability of fish being able to alter course and successfully exit the Delta, although the magnitude of this effect is currently unknown due to a lack of data regarding fine scale fish movement behavior and survival in those reaches under export conditions. This is particularly important for CV spring-run Chinook salmon that originate in the San Joaquin River basin and enter the Old River channel. These fish would migrate downstream in either the Old River, Middle River, or Grant Line/ Fabian – Bell channels. All three channels have considerable exposure to the effects of exports. The Old River and Grant Line/ Fabian –Bell channels pass directly in front of or in very close proximity to the intakes for the CVP and SWP, and a large proportion of fish moving through these channels are expected to be entrained into the fish collection facilities where high levels of mortality are expected. The Middle River channel joins with the man-made Victoria Canal/ North Canal, a large dredged channel directly leading to the export facilities, and net flows move towards the export facility intakes under most conditions.

Increased export has negative far-field migratory impacts as well, particularly in the Old and Middle River corridors which would negatively affect CV spring-run Chinook salmon in those corridors. Fish that are present in the Old River or Middle River corridors and their distributaries downstream of the south Delta export facilities would experience increased net flows towards the export facilities. Increased exports would mute the ebbing tide signal to cue fish to move out of those corridors and back into the main migratory corridor of the San Joaquin River rather than moving farther southwards into waters that are more heavily influenced by the effects of reverse flows due to exports. This would affect both juvenile CV spring-run Chinook salmon originating in the Sacramento River basin as well as those CV spring-run Chinook salmon originating in the San Joaquin River basin and migrating downstream within the main stem channel of the San Joaquin River from upstream locations.

Flows under the proposed action will result in less flow in the San Joaquin River corridor, thereby decreasing survival for CV spring-run Chinook salmon originating in the San Joaquin River basin and entering the South Delta and interior Delta through this route. There are two main reasons for these impacts. Less downstream flow in the San Joaquin River channel downstream of the confluence with the Head of Old River in conjunction with increased exports was modeled to slightly shift the velocity density to more negative velocities (more upstream flows), potentially indicating more tidal effect in this reach under the proposed action. This shift in tidal influence tends to direct more flow (and migrating fish) into Old River due to the tidal forcing of the flood tide moving upriver in the main stem of the San Joaquin River. The modeling of the velocity density indicated that within the main stem San Joaquin River near its junction with the Mokelumne River and farther downstream at Jersey Point, there was a high degree of overlap between the proposed action and current operating scenario due to the overwhelming tidal influence. Therefore, in this portion of the main stem San Joaquin River, there is little difference between the proposed action and the current operating scenario. However, survival in these reaches are considered to be low due to the influence of the tides prolonging migration transit times and increasing exposure to predators along the route.

As discussed in the winter-run Chinook salmon section above, it is an important concept to note that even though the absolute numbers of fish lost in the drier water year types under current conditions are lower than during wetter water year types, this is also a function of overall watershed survival differences between water year types as well as the magnitude of exports. During wet water years, more juvenile salmonids enter the south Delta from either basin and greater numbers are, therefore, exposed to the export facilities (Brandes and McLain 2001; Kjelson et al. 1982; Newman and Brandes 2010). Lower numbers of fish lost in drier years, therefore, does not necessarily indicate that restrictions on pumping are impacting a smaller proportion of fish, but that there is potentially a smaller pool of fish present to be entrained. The effects of more negative Old and Middle River flows have already been discussed for winter-run Chinook salmon and NMFS expects that they will have similar impacts upon CV spring-run Chinook salmon.

8.6.9.2.5 CCV Steelhead Exposure

Using the current methodology for calculating salvage and loss, based on expansion of observed salvaged fish and using the current loss multipliers, the estimated average annual cumulative clipped juvenile CCV steelhead salvage and loss from brood year 1999 to 2017 for the SWP and CVP were 2,798 and 6,990 juveniles, respectively (Table 88). The average proportional loss for the years 1999-2014 (incomplete hatchery release data were available for 2015-2017), which is the annual cumulative total loss divided by the annual number of hatchery-reared and released steelhead juveniles, was 0.50 percent (Table 88). Since 1998, all hatchery-produced steelhead that are released into the waters of the Central Valley are adipose fin clipped to allow them to be distinguished from natural fish. The average annual cumulative unclipped (natural) juvenile CCV steelhead salvage and loss from brood year 1999 to 2017 for the SWP and CVP were 1,324 and 3,110 juveniles, respectively (Table 88).

Table 88. Unclipped (natural origin) annual juvenile California Central Valley steelhead salvage and loss from Brood Years 1998 to 2017.

Brood Year	Total Fish Salvage	Total Fish Loss
1998	2,211	6,353
1999	3,728	8,299
2000	4,458	8,655
2001	1,576	4,414
2002	2,146	4,716
2003	1,761	4,087
2004	1,215	2,460
2005	1,201	2,313
2006	2,756	8,395
2007	970	1,716
2008	360	932
2009	941	2,783
2010	557	800
2011	324	517
2012	744	1,600
2013	185	660
2014	43	157
2015	119	293
2016	65	194
2017	1,119	2,852
Mean	**1,324**	**3,110**
Median	**1,045**	**2,387**
SD	**1,226**	**2,854**
95 percent CI	**574**	**1,336**

As discussed previously for juvenile winter-run Chinook salmon and CV spring-run Chinook salmon, there are many issues that influence the movement and vulnerability of juvenile CCV steelhead to entrainment, salvage, and loss at the fish collection facilities for the CVP and SWP. Comparable to the winter-run Chinook salmon and CV spring-run Chinook salmon populations, the majority of CCV steelhead originate in the Sacramento River basin and, thus, follow a common emigration pathway to the Delta through the main stem of the Sacramento River. Factors which influence the routing and survival of Chinook salmon juveniles will also influence the routing and survival of juvenile CCV steelhead. Like juvenile spring-run originating from the experimental population in the San Joaquin River basin, juvenile CCV steelhead emigrating out of the San Joaquin River basin (Southern Sierra diversity group) face the necessity of surmounting obstacles unique to the San Joaquin River basin, including the actions of the south Delta agricultural barriers, and migrating through the waterways of the south Delta as the primary route to the ocean and not as a secondary route as seen for the Sacramento River basin fish.

The discussion of the effects of south Delta export facilities operations that has already been described for winter-run Chinook salmon and CV spring-run Chinook salmon would be applicable to CCV steelhead. Juvenile CCV steelhead migration through the Delta overlaps with both the migration timing of winter-run Chinook salmon and CV spring-run Chinook salmon, and, therefore, the discussion from both Chinook salmon races would be expected to apply to CCV steelhead, too. In the San Joaquin River basin, comparisons to CV spring-run Chinook salmon are especially appropriate, as NMFS expects juveniles from both salmonid groups will be migrating out of the San Joaquin River basin at the same time and will experience the same hydrologic and operational effects during their movements.

8.6.9.2.6 Juvenile Salvage Estimates using the Salvage-Density Method

The salvage density method relies on historic exports and observed loss (for water years 1995 to 2009) of salmonids at the CVP and SWP collection facilities and essentially functions as a description of changes in export flows weighted by seasonal changes in loss. The results of the salvage-density method showed that, based on modeled south Delta exports, annual loss of CCV steelhead at the south Delta export facilities would be 15 percent (in Above Normal years) to 38 percent (in Critical years) higher under the proposed action than the current operating scenario (Table 89). The monthly loss of CCV steelhead at the south Delta export facilities (Table 90) shows that the largest increases in loss occur in April (153 percent), and May (132 percent). The majority of steelhead outmigration from the San Joaquin Basin occurs during the April-May period, so while much overall steelhead salvage occurs prior to April, the risk of increased loss during April and May will affect the majority of San Joaquin-origin steelhead outmigrants. It is possible that some of the loss modeled to occur at the export facilities under the proposed action water flow might have occurred due to far-field effects in the south Delta under current operating scenario conditions before fish arrived at the CVP or SWP facilities. Some of this far-field loss may be attributable to the effects of the SWP and CVP export operations, but no modeling tool is available that quantifies that loss and allows comparison of both direct loss and far-field effects under proposed action vs. current operating scenario conditions associated with the SWP and CVP export operations.

Table 89. Estimated annual loss of California Central Valley steelhead at the export facilities by water year type based on the salvage-density method.

Water Year Type	Loss Under Current Operating Scenario	Loss Under Proposed Action	Proposed Action minus Current Operating Scenario	Change
Wet	6,560	7,988	1,428	22%
Above Normal	12,558	14,489	1,932	15%

Water Year Type	Loss Under Current Operating Scenario	Loss Under Proposed Action	Proposed Action minus Current Operating Scenario	Change
Below Normal	10,188	12,056	1,867	18%
Dry	9,743	12,478	2,735	28%
Critical	5,158	7,107	1,949	38%

Table 90. Estimated annual loss of California Central Valley steelhead at the export facilities by month for all water types based on the salvage-density method.

Water Year Type	Loss Under Current Operating Scenario	Loss Under Proposed Action	Proposed Action minus Current Operating Scenario	Change
October	40	60	20	48%
November	14	16	2	16%
December	43	38	-5	-12%
January	1,447	1,533	86	6%
February	1,756	1,809	54	3%
March	1,995	1,880	-116	-6%
April	604	1,528	923	153%
May	354	822	467	132%
June	269	267	-1	0%
July	31	29	-1	-4%
August	3	3	0	-1%
September	4	4	0	2%

NMFS put the combined CCV steelhead loss in a population context (see full caveats in Section 2.5.5.8.3.1) by expressing the estimated annual combined loss as a percentage of the steelhead population in the Delta. These results should be considered a coarse screening level analysis due to limitations of the salvage-density method itself (limited historical time-frame of loss; relatively simple weighting of loss by export changes and no other operational factors) and use of the average annual modeled loss rates (over the 15-year data period) scaled to both low and high population estimates. Since it is likely that annual observed loss in a particular year is correlated with population size, use of the average loss rate likely overestimates the population effect in a low-population year, and underestimates the population effect in a high-population year.

Estimated annual combined loss from the current operating scenario is 6,560 juveniles, and estimated annual combined loss from the proposed action is 7,988. Good et al. (2005) estimated the CCV steelhead population at approximately 94,000-336,000 juveniles, and (Nobriga and Cadrett 2001)estimated the CCV steelhead population at 413,069-658,453 juveniles. Applying the estimated annual combined loss to the lowest and highest juvenile population estimates provides ranges of 1 (6,560 ÷ 658,453) to 7 (6,560 ÷ 94,000) percent loss of the juvenile CCV steelhead population in the Delta for the current operating scenario, and 1 (7,988 ÷ 658,453) to 8 (7,988 ÷ 94,000) percent loss of the juvenile CCV steelhead population in the Delta for the proposed action. Since it is likely that annual observed loss in a particular year is correlated with population size, use of the average loss rate likely overestimates the population effect in a low-population year, and underestimates the population effect in a high-population year.

The results of the salvage-density method showed that, based on modeled south Delta exports, mean loss at the south Delta export facilities would be higher under the proposed action than the current operating scenario in all water year types for CCV steelhead. The absolute differences between the proposed action and the current operating scenario were similar in most water year types (1,250 to 1,600 fish), except in dry years when the difference between the proposed action and current operating scenario was estimated as 2,249 fish for the SWP and 486 for the CVP (Table 91). For CCV steelhead, the differences ranged from 13.3 percent more under the proposed action at the CVP in below normal years to 38.8 percent more under the proposed action at the SWP in critical years (Table 92). Within years, the monthly estimated loss varied considerably. The estimated loss rates were typically higher in April and May for all water year types for the proposed action compared to the current operating scenario. However, March had lower loss values in wet years for the proposed action compared to the current operating scenario conditions, but higher values in drier years (Table 93, Table 94, Table 95, and Table 96). The largest percentile differences between the proposed action and current operating scenario occurred in April and May, where the proposed action loss rate could be as much as 238 percent higher than the current operating scenario conditions (April, above normal years and below normal years (Table 93 and Table 94) and loss values were typically at least 75 percent higher for the other water year types. This difference reflects the substantial increase in exports during April and May under the proposed action compared to the current operating scenario conditions.

Table 91. Estimated number juvenile California Central Valley steelhead lost due to entrainment at the export facilities by type of water year.

Water Year Type	-	-	State Water Project	-	-	Central Valley Project
--	current operating scenario	PA	PA – current operating scenario (percent change)	current operating scenario	PA	PA v current operating scenario (percent change)
Wet	5,440	6,692	1252 (23.0 %)	1,120	1,296	177 (15.8%)
Above Normal	10,208	11,813	1605 (15.7%)	2,349	2,676	327 (13.9%)
Below Normal	7,097	8,552	1456 (20.5%)	3,092	3,503	412 (13.3%)
Dry	7,573	9,822	2249 (29.7%)	2,170	2,656	486 (22.4%)
Critical	4,102	5,694	1592 (38.8%)	1,056	1,413	357 (33.8%)

Table 92. Estimated number juvenile California Central Valley steelhead lost due to entrainment at the export facilities in wet water years.

Month	-	-	State Water Project	-	-	Central Valley Project
--	current operating scenario	PA	PA – current operating scenario (percent change)	current operating scenario	PA	PA v current operating scenario (percent change)
October	40	60	20 (48.5%)	0	0	0
November	11	13	2 (16.7%)	3	3	0 (12.2%)
December	38	33	-5 (-12.4%)	5	5	0 (-7.0%)
January	1,253	1,338	85 (6.8%)	194	194	0 (0.1%)
February	1,507	1,578	71 (4.7%)	249	231	-18 (-7.1%)
March	1,600	1,494	-106 (-6.6%)	395	386	-9 -2.4%)
April	465	1,246	781 (168.0%)	139	282	143 (102.3%)
May	297	699	401 (135.0%)	57	123	66 (115.4%)
June	217	219	2 (1.0%)	52	48	-3 (-6.7%)
July	4	4	0(2.3%)	26	25	-1 (-5.0%)
August	3	3	0 (-1.4%)	0	0	0
September	4	4	0 (1.7%)	0	0	0
Annual Average	5,440	6,692	1,252 (23.0%)	1,120	1,296	177 (15.8%)

Table 93. Estimated number juvenile California Central Valley steelhead lost due to entrainment at the export facilities in above normal water years.

Month	-	-	State Water Project	-	-	Central Valley Project
--	current operating scenario	PA	PA – current operating scenario (percent change)	current operating scenario	PA	PA v current operating scenario (percent change)
October	4	5	1 (32.5%)	0	0	0
November	29	35	6 (20.3%)	7	6	-1 (-12.6%)
December	303	304	0 (0.1%)	31	31	0 -0.5%)
January	2,796	3,345	550 (19.7%)	1,014	1,101	87 (8.5%)
February	4,618	4,755	137 (3.0%)	768	775	7 (0.9%)
March	1,978	1,886	-92 (-4.7%)	400	397	-3 (-0.8%)
April	289	979	690 (238.2%)	80	223	143 (178.1%)
May	130	437	307 (236.0%)	42	137	95 (228>7%)
June	53	60	7 (13.0%)	7	6	-1 (-10.8%)
July	8	8	0 (6.1%)	2	2	0 (-3.4%)
August	0	0	0	0	0	0
September	0	0	0	0	0	0
Annual Average	10,208	11,813	1,605 (15.7%)	2,349	2,676	327 (13.9%)

Table 94. Estimated number juvenile California Central Valley steelhead lost due to entrainment at the export facilities in below normal water years.

Month	-	-	State Water Project	-	-	Central Valley Project
--	current operating scenario	PA	PA – current operating scenario (percent change)	current operating scenario	PA	PA v current operating scenario (percent change)
October	0	0	0	0	0	0
November	0	0	0	0	0	0
December	113	103	-10 (-9.0%	8	7	-1 (-7.6%)
January	331	386	55 (16.7%)	63	68	5 (8.3%)
February	4,324	5,208	885 (20.5%)	2,164	2,456	292 (13.5%)
March	2,227	2,577	349 (15.7%)	782	801	19 (2.4%)
April	47	122	74 (155.8%)	42	81	40 (94.4%)
May	54	157	103 (188.7%)	34	90	57 (167%)

Month	-	-	State Water Project	-	-	Central Valley Project
June	0	0	0	0	0	0
July	0	0	0	0	0	0
August	0	0	0	0	0	0
September	0	0	0	0	0	0
Annual Average	7,097	8,552	1,456 (20.5%)	3,092	3,503	412 (13.3%)

Table 95. Estimated number juvenile California Central Valley steelhead lost due to entrainment at the export facilities in dry water years.

Month	-	-	State Water Project	-	-	Central Valley Project
--	current operating scenario	PA	PA – current operating scenario (percent change)	current operating scenario	PA	PA v current operating scenario (percent change)
October	2	3	1 (32.4%)	0	0	0
November	43	52	9 (21.0%)	2	2	0 (-7.7%)
December	93	94	0 (0.5%)	3	2	0 (-9.0%)
January	621	647	25 (4.1%)	73	74	1 (1.0%)
February	2,437	2,911	474 (19.4%)	702	894	192 (27.4%)
March	3,539	4,552	1,012 28.6%)	1,121	1,296	175 (15.6%)
April	634	1,162	527 (83.2%)	243	339	97 (39.8%)
May	177	370	193 (108.7%)	20	39	19 (94.5%)
June	14	22	8 (59.8%)	7	10	3 (39.8%)
July	12	10	-2 (-13.1%)	0	0	0
August	0	0	0	0	0	0
September	0	0	0	0	0	0
Annual Average	7,573	9,822	2,249 (29.7%)	2,170	2,656	486 (22.4%)

Table 96. Estimated number juvenile California Central Valley steelhead lost due to entrainment at the export facilities in critical water years.

Month	-	-	State Water Project			Central Valley Project
--	current operating scenario	PA	PA – current operating scenario (percent change)	current operating scenario	PA	PA v current operating scenario (percent change)
October	0	0	0	0	0	0

Month	-	-	State Water Project			Central Valley Project
November	0	0	0	0	0	0
December	0	0	0	0	0	0
January	196	200	3 (1.6%)	234	239	5 (2.0%)
February	2,944	3,975	1,031 (35.0%)	624	885	261 (41.8%)
March	644	924	280 (43.4%)	141	221	79 (56.1%)
April	187	348	161 (86.1%)	46	54	8 (17.2%)
May	111	194	83 (74.5%)	10	14	4 (39.6%)
June	10	43	33 319.6%)	0	0	0
July	9	10	1 (9.7%)	0	0	0
August	0	0	0	0	0	0
September	0	0	0	0	0	0
Annual Average	4,102	5,694	1,592 (38.8%)	1,056	1,413	357 (33.8%)

8.6.9.2.7 Southern Distinct Population Segment Green Sturgeon Exposure

In recent years (2011-2018) only eight green sturgeon have been salvaged, four at the SWP (2016) and four at the CVP (2017). For the period from 1981 to 2018, the estimated annual cumulative expanded salvage of green sturgeon between the CVP and SWP has ranged between zero and 1,476 fish, with a mean annual cumulative salvage of 200 fish using current methods for expanding salvage counts. However, since the late 1980s, expanded cumulative annual salvage has been substantially less than this.

8.6.9.2.8 Juvenile Salvage Estimates using the Salvage-Density Method

The salvage density method relies on historic exports and observed salvage (for water years 1995-2009) of sturgeon at the CVP and SWP fish salvage facilities and essentially functions as a description of changes in export flows weighted by seasonal changes in salvage (see caveats in Section 2.5.5.8.3.1). The results of the salvage-density method showed that, based on modeled south Delta exports, average sDPS green sturgeon salvage at the south Delta export facilities would be slightly higher under the proposed action than the current operating scenario. The biggest differences would occur in wet years with the proposed action modeled as having between 4.4 percent (SWP) and 9.3 percent (CVP) more fish salvaged during wet water year types. Due to the rarity of sDPS green sturgeon in salvage, these numbers are typically represented by only a very small numbers of fish (Table 97, Table 98, Table 99, Table 100, Table 101, and Table 102).

Table 97. Estimated entrainment index[1] of juvenile green sturgeon for the proposed action and current operating scenario scenarios at the export facilities in wet water years.

Month	-	-	State Water Project	-	-	Central Valley Project
--	current operating scenario	PA	PA – current operating scenario (percent change)	current operating scenario	PA	PA v current operating scenario (percent change)
October	3	5	2 (48.5%)	8	8	0
November	6	7	1 (16.7%)	4	4	0
December	0	0	0	10	9	-1 -7.0%)
January	2	2	0	0	0	0
February	42	44	2 (4.7%)	0	0	0
March	4	3	0	0	0	0
April	0	0	0	2	3	2 (102.3%)
May	0	0	0	5	11	6 (115.4%)
June	2	2	0	7	7	0 (-6.7%)
July	1	1	0	20	19	-1 (-5.0%)
August	30	30	0	5	5	0 (0.4%)
September	18	18	0	12	13	0 (3.7%)
Annual Average	107	112	5 (4.4%)	73	80	7 (9.3%)

[1] *Entrainment index is the number of fish salvaged, based on salvage data and the salvage-density method*

Table 98. Estimated entrainment index of juvenile green sturgeon for the proposed action and current operating scenario scenarios at the export facilities in above normal water years.

Month	-	-	State Water Project			Central Valley Project
--	current operating scenario	PA	PA – current operating scenario (percent change)	current operating scenario	PA	PA v current operating scenario (percent change)
October	0	0	0	0	0	0
November	0	0	0	0	0	0
December	0	0	0	0	0	0
January	2	3	1 (19.7%)	0	0	0
February	6	6	0 (3.0%)	0	0	0
March	0	0	0	0	0	0
April	0	0	0	0	0	0
May	0	0	0	0	0	0
June	0	0	0	0	0	0
July	4	4	0	0	0	0

Month	-	-	State Water Project			Central Valley Project
August	0	0	0	0	0	0
September	0	0	0	0	0	0
Annual Average	12	12	1 (7.1%)	0	0	0

Table 99. Estimated entrainment index of juvenile green sturgeon for the proposed action and current operating scenario scenarios at the export facilities in below normal water years.

Month	-	-	State Water Project	-	-	Central Valley Project
--	current operating scenario	PA	PA – current operating scenario (percent change)	current operating scenario	PA	PA v current operating scenario (percent change)
October	0	0	0	0	0	0
November	0	0	0	0	0	0
December	0	0	0	0	0	0
January	0	0	0	0	0	0
February	0	0	0	0	0	0
March	0	0	0	0	0	0
April	0	0	0	0	0	0
May	0	0	0	0	0	0
June	0	0	0	0	0	0
July	0	0	0	0	0	0
August	0	0	0	0	0	0
September	0	0	0	0	0	0
Annual Average	0	0	0	0	0	0

Table 100. Estimated entrainment index of green sturgeon for the proposed action and current operating scenario scenarios at the export facilities in dry water years.

Month	-	-	State Water Project	-	-	Central Valley Project
--	current operating scenario	PA	PA – current operating scenario (percent change)	current operating scenario	PA	PA v current operating scenario (percent change)
October	0	0	0	19	21	2 (8.7%)
November	1	1	0 (21.0%)	25	23	-2 (-7.7%)
December	16	16	0 (0.5%)	8	7	-1 (-9.0%)
January	0	0	0	3	4	0 (1.0%)
February	0	0	0	0	0	0

Month	-	-	State Water Project	-	-	Central Valley Project
March	4	5	1 (28.6%)	0	0	0
April	0	0	0	0	0	0
May	0	0	0	0	0	0
June	0	0	0	0	0	0
July	0	0	0	0	0	0
August	0	0	0	0	0	0
September	0	0	0	0	0	0
Annual Average	21	22	1 (6.6%)	55	55	-1 (-1.6%)

Table 101. Estimated entrainment index of juvenile green sturgeon for proposed action and current operating scenario scenarios at the export facilities in critical water years.

Month	-	-	State Water Project	-	-	Central Valley Project
--	current operating scenario	PA	PA – current operating scenario (percent change)	current operating scenario	PA	PA v current operating scenario (percent change)
October	0	0	0	0	0	0
November	0	0	0	0	0	0
December	0	0	0	0	0	0
January	0	0	0	4	4	0 (2.0%)
February	0	0	0	0	0	0
March	0	0	0	0	0	0
April	0	0	0	3	4	1 (17.2%)
May	0	0	0	0	0	0
June	0	0	0	0	0	0
July	0	0	0	0	0	0
August	0	0	0	0	0	0
September	0	0	0	0	0	0
Annual Average	0	0	0	8	9	1 (8.7%)

Table 102. Estimated entrainment index[1] of juvenile green sturgeon for proposed action and current operating scenario scenarios at the export facilities by water year type.

Water Year Type	-	-	State Water Project	-	-	Central Valley Project
--	current operating scenario	PA	PA – current operating scenario (percent change)	current operating scenario	PA	PA v current operating scenario (percent change)
Wet	107	112	5 (4.4 %)	73	80	7 (9.3 %)
Above Normal	12	12	1 (7.1 %)	0	0	0 (0.0 %)
Below Normal	0	0	0 (0.0 %)	0	0	0 (0.0 %)
Dry	21	22	1 (6.6 %)	55	55	-1 (-1.6 %)
Critical	0	0	0 (0.0 %)	8	9	1 (8.7 %)

[1] Number of fish salvaged, based on historical salvage data and the salvage-density methods

8.6.9.2.9 Species responses to Old and Middle River Flow Management

Note: Much of the description in this section is based on an earlier version of the proposed action that subsequently changed during the course of the consultation. A supplemental analysis based on proposed action revisions received June 14, 2019 is provided in Section 8.6.12.9. We carried the findings of the supplemental analysis into the Integration and Synthesis section of this Opinion.

The following discussion addresses the potential responses of listed salmonids and sDPS green sturgeon to the proposed Old and Middle River flow management plan. As previously stated, increasing exports increases the probability of fish entrainment into the fish salvage facilities through alterations in the near- and far-field hydrodynamics of the south Delta. Measuring Old and Middle River flows is a proxy for determining the influence of exports and Vernalis inflow on the local hydrodynamic field surrounding the export facilities in the south Delta waterways.

8.6.9.2.10 Onset of Old and Middle River Flow Management

The Old and Middle River flow management proposed action (April 30, 2019; (U.S. Bureau of Reclamation 2019a)) component requires several assumptions to be made for its implementation. The following assumptions are made regarding the implementation of this proposed action component:

- The Delta monitoring group assesses the percentage of population present in the Delta in a manner similar to the current Delta operations for salmonids and sturgeon group.
- Similar or better information is available to the Delta monitoring group than the Delta operations for salmonids and sturgeon group.

8.6.9.2.11 Integrated Early Water Pulse Protection (First Flush) Turbidity Event

Although this proposed action component is specifically designed to protect Delta smelt during their upstream movements prior to spawning, it may provide protective benefits to emigrating juvenile salmonids. This proposed action component will be implemented following a "First Flush" event in the Delta that is triggered when there are flows greater than 25,000 cfs on the Sacramento River, as measured at Freeport on a 3-day running average coupled with a 3-day running daily average turbidity of 50 NTU at Freeport during the period of December 1 through January 31. The proposed action component may only occur once during this period. If the required conditions exist, Reclamation and DWR will reduce exports for 14 consecutive days to achieve an Old and Middle River index flow that will be no more negative than -2,000 cfs[14] over the 14-day averaged flow. The reduced export environment will be beneficial to any listed salmonids or sDPS green sturgeon in the vicinity of the export facilities that could encounter near-field or far-field effects of the exports. A more positive Old and Middle River would be expected to change the local hydrodynamics resulting in reduced entrainment into the facilities, and reduced alterations to the routing of migrating fish into the south delta region from the north.

As previously stated in this document, during the period of the "First Flush" proposed action component from December 1 through January 31, juvenile winter-run Chinook salmon and yearling CV spring-run Chinook salmon would be expected to initiate their emigration into the Delta when precipitation events in the upper Sacramento River watershed cause flows in the main stem to increase substantially. Flows in excess of approximately 14,000 cfs on the Sacramento River (as measured at Wilkins Slough) have been shown to be an indication that emigration of juvenile winter-run Chinook salmon will occur (del Rosario et al. 2013). Similarly, increases in flows in Sacramento River tributaries such as Deer Creek and Mill Creek over 95 cfs have been correlated with emigration of yearling CV spring-run Chinook salmon juveniles from those watersheds. The triggers described for the "First Flush" protective proposed action component would also indicate that environmental conditions are present that would stimulate emigration of listed salmonids (winter-run Chinook salmon and yearling CV spring-run Chinook salmon) into the Delta. The amount of overlap between the initiation of salmonid emigration and the "First Flush" proposed action component would depend upon the timing of storm events and flows in the Sacramento River. If the first major storm event of the winter rainy season occurred during the December through January implementation period, and produced the appropriate flow and turbidity conditions to trigger the "First Flush" proposed action component, then there would be a high level of overlap between winter-run Chinook salmon and yearling CV spring-run Chinook salmon emigration and the protective proposed action component. On the other hand, if smaller storms came through earlier in the season that did not create the conditions necessary to trigger the "First Flush" proposed action component, but were sufficient to raise Sacramento River flows over 14,000 cfs at Wilkins Slough, then the expectation is that salmonid emigration will have already started and the overlap with the "First Flush" proposed action component will not occur to the same extent if conditions eventually occur later in the season that trigger the action. It is also possible that the conditions to initiate the "First Flush" will not occur in a given year, and thus there is no protective proposed action component taken and no benefits to listed salmonids of the reduced exports.

8.6.9.2.12 Salmonid Onset Triggers

Reclamation and DWR proposed that Old and Middle River flows will be no more negative than -5,000 cfs after January 1 if more than five percent of any one or more unclipped listed salmonid

[14] At a May 21, 2019, consultation meeting on the Delta, Reclamation confirmed the OMR limit during a "First Flush" event should be -2,000 cfs.

species (winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead) are estimated to be present in the Delta as determined by "real-time" monitoring data and the advice of a Delta-specific working group. The proposed action component incorporates a percentage of listed salmonid population in the Delta metric to initiate Old and Middle River management and that management of Old and Middle River flows cannot start any earlier than January 1. It is possible under this new metric that management of Old and Middle River flow levels may not start on January 1, if none of the listed salmonid species has at least 5 percent of the population in the Delta by January 1. If this condition exists, these listed fish in the Delta would not have any of the protections afforded by an Old and Middle River management action that maintains flows at no more negative than -5,000 cfs.

The Salmonid Scoping Team was asked to evaluate the effectiveness of the Old and Middle River onset criteria in the NMFS 2009 CVP/SWP Operations opinion which is reflected in the current operating scenario scenario. Since January 1 plays a role in both the current operating scenario and the proposed action, NMFS considers that evaluation relevant for understanding the potential effects of the proposed action on salmonids and reviews those results here. Salmonid Scoping Team (2017b) concluded that the "January 1 onset of Old and Middle River reverse flow management coincides with the presence of protected salmonids in the Delta in almost all years, but an earlier onset would often be more effective for some listed salmonids. 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." Furthermore, Salmonid Scoping Team (2017b) reported that "while initiating Old and Middle River flow restrictions on January 1 each year provided protection, initiating the restrictions prior to January 1 would have provided better protection for winter-run Chinook salmon. This is because these fish were detected prior to January 1 in the Delta in all but one year from 1995 to 2015." The Salmon Scoping Team concluded that "in most years, improved protection of Sacramento River salmonid populations from export effects would be provided if the onset date of Old and Middle River reverse flow management were triggered by detection of migrants at monitoring stations located on the Sacramento River upstream of distributary junctions leading toward the San Joaquin River."

Based on the historical record, winter-run Chinook salmon are the listed salmonid species most likely to be in the Delta on January 1 with more than five percent of its brood year population present. Using the information from the retrospective compilation of data from Sacramento trawls at Sherwood Harbor, the average date by which five percent of the population passes Sherwood Harbor (site of the Sacramento trawls) is December 17 (median date December 11). On average, 25 percent of the winter-run population is in the Delta by January 9 (median date December 29) which indicates that for the endangered winter-run Chinook salmon population, approximately 20 to 25 percent of the population is already in the Delta prior to any protective Old and Middle River flow management actions being implemented on January 1 (Table 55). The timing of CV spring-run Chinook salmon and CCV steelhead emigrations indicate that these populations do not enter the Delta (based on the Sacramento trawl data) until the end of January and into early February (Table 56 and Table 57.). Old and Middle River flow management actions are not taken for any life stage of sDPS green sturgeon, as they are assumed to be present in the Delta year-round. Real time estimates of listed salmonid presence in the Delta by the Delta operations for salmonids and sturgeon working group only includes natural juvenile winter-run Chinook salmon and CV spring-run Chinook salmon. The Delta operations for salmonids and sturgeon working group currently does not make any estimates of the distribution of the natural origin juvenile CCV steelhead population, given the difficulty of monitoring for this species. Juvenile CCV steelhead are difficult to capture in the trawls and rotary screw traps used in the Central Valley monitoring programs as they can easily avoid them, thus making any assessment to population distribution uncertain.

The proposed onset of Old and Middle River based on salmonid triggers, for the most part, would not often be different than current operations under the current operating scenario conditions, with Old and Middle River flow management restrictions likely starting on January 1 except in the driest of years when juvenile migration occurs after January 1. Listed salmonids entering the Delta prior to January 1 would not have any protection from elevated exports, and may be exposed to Old and Middle River flows more negative than -5,000 cfs unless first flush conditions have triggered an Old and Middle River action that targets protecting Delta Smelt

In those infrequent years when emigration of winter-run Chinook salmon is delayed by upstream flow conditions, the entry of the bulk of the juvenile winter-run Chinook salmon population into the Delta would be delayed until precipitation events create the right conditions to stimulate emigration. However, a proportion of the winter-run Chinook salmon population (and likely yearling spring-run Chinook salmon too) would continue to trickle into the Delta in low numbers under these low flow conditions prior to the main migration movement. This would place up to 5 percent of early migrants at risk of entrainment or having their migratory routes altered as discussed previously for export impacts in this document. This would potentially decrease the diversity of the life history strategies of the Chinook salmon and steelhead populations by not protecting these early emigrants to the Delta, and exposing them to high export conditions with more negative Old and Middle River flows.

8.6.9.2.13 End of Old and Middle River Flow Management

Reclamation and DWR proposed to end Old and Middle River flow management actions on June 30 at the latest, or when both of the following conditions are met, whichever is earlier:

- For Delta smelt protection, the condition for ending Old and Middle River flow management is when the mean water temperature in Clifton Court Forebay reaches 25°C (77°F) for three consecutive days.
- For listed salmonid protections, the conditions for ending Old and Middle River flow management is when 95 percent of the listed population has migrated past Chipps Island as determined by the Delta monitoring work group, or, the daily average water temperature at Mossdale has exceeded 72°F (22.2°C) for 7 days during June. The water temperature days in June do not need to be consecutive.

In most years, the conditions for Delta smelt are likely to be the limiting factor, as water temperatures of 25°C (77°F) for 3 consecutive days in Clifton Court Forebay typically occurs after water temperatures at Mossdale exceed 72°F and both conditions must be met to end Old and Middle River flow management. The criteria requiring 95 percent of a given listed salmonid population to have migrated past Chipps Island before ending the Old and Middle River flow management actions will typically be driven by the distribution of CV spring-run Chinook salmon, based on Chipps Island monitoring. Typically, at least 95 percent of winter-run Chinook salmon and CV spring-run Chinook salmon have left the Delta prior to the beginning of June. On average, the date of all winter-run Chinook salmon passing Chipps Island is April 28. The average date for 95 percent of the annual CV spring-run Chinook salmon brood year passing Chipps Island is May 8. For CCV steelhead, the average date by which 95 percent of the annual population has past Chipps Island is April 28, based on information from the SacPas website (www.cbr.washington.edu/sacramento/). These dates are derived from retrospective analysis of the Chipps Island trawl data. While the current Delta operations for salmonids and sturgeon working group does make estimates of CV spring-run Chinook salmon distribution in the Delta, Delta operations for salmonids and sturgeon does note that those estimates are very uncertain once hatchery fall-run Chinook salmon are present in the system. Since most monitoring locations use length-at-date criteria to assign fish to run, and many of the unmarked 75 percent of the hatchery releases may fall into the CV spring-run Chinook salmon size class, it becomes more difficult to interpret the data on spring-run-sized fish. Since the current Delta operations for salmonids and sturgeon working group does not make any assessments of CCV steelhead distribution in the Delta, there is no existing information to use for how the group will assess late season steelhead distribution and whether it will track with the data in the website in real time.

The current management of Old and Middle River flows, with the cap on Old and Middle River flows not being more negative than -5,000 cfs during the salmonid migratory period, continues through June 15, with an offramp if there are 7 consecutive days of water temperatures exceeding 72°F (22°C) after June 1. This restriction on Old and Middle River flows was designed in part to protect late emigrating salmonids, particularly CCV steelhead from the San Joaquin River basin that typically migrate out of the system in April and May. The Chipps Island trawl data for CCV steelhead are heavily biased by the much larger population of CCV steelhead originating in the Sacramento River basin. Thus, the earlier date of April 28 for the time when 95 percent of the current year’s juvenile CCV steelhead population has passed Chipps Island is skewed by the differences in the Sacramento and San Joaquin river basins CCV steelhead populations. The date reflects the dominate size of the Sacramento River basin population and its migratory patterns, and not necessarily the migratory behavior of the smaller San Joaquin River basin steelhead population.

Therefore, the proposed end of Old and Middle River management poses a greater risk to San Joaquin River CCV steelhead than the current management of Old and Middle River flows under the current operating scenario. There is the potential to end Old and Middle River flow management prior to the completion of the San Joaquin River basin’s steelhead outmigration, and place these fish at greater risk of entrainment at the export facilities or alterations of their migratory routing, leading to increased transit times and distance, resulting in reduced survival.

8.6.9.2.14 Additional Real-time Old and Middle River Management Actions

8.6.9.2.15 Turbidity Bridge Avoidance

Reclamation and DWR propose to implement proposed action components designed to avoid creating a turbidity bridge between the main stem of the San Joaquin River to the north, and the export facilities to the south to protect adult Delta smelt that may be present in the main stem of the San Joaquin River from moving southwards towards the export facilities. This proposed action component will be implemented after the completion of the integrated early winter pulse protection action (First Flush) or by February 1, whichever comes first. Exports will be managed to maintain a daily turbidity average at the Old River at Bacon Island monitoring site at a level less than 12 NTU. If turbidity does not exceed 12 NTU, there is no explicit Old and Middle

River limits for protecting Delta smelt. If daily turbidity levels exceed 12 NTU, the 3-day average Old and Middle River index values will not be more negative than -2,000 cfs until the 3-day average turbidity at Old River at Bacon Island falls below the 12 NTU threshold. This proposed action component will be implemented from February 1 to March 31, even if the first flush action has not occurred earlier in the year. This proposed action component will not be required on or after April 1.

This proposed action component has the potential to be beneficial to listed salmonids or sDPS green sturgeon if the turbidity criteria are exceeded and the Old and Middle River flows are capped at being no more negative than -2,000 cfs during the turbidity bridge event. However, if the turbidity criteria for protecting Delta smelt has not been met and if the criteria for protecting salmonids during this period has not occurred (i.e., more than five percent of any listed salmonid population is in the Delta after January 1), then any listed salmonids or sDPS green sturgeon present in the Delta would be vulnerable to the effects of the elevated exports allowed under this proposal, since there are no explicit Old and Middle River limits required for protecting Delta smelt. However, it would be unlikely that there would not be at least one population of listed salmonids that would have at least five percent of their population in the Delta at this time (likely winter-run Chinook salmon) and, thus, there would already be the requirement that Old and Middle River flows be no more negative than -5,000 cfs to protect listed salmonids from the effects of high exports.

8.6.9.2.16 Larval and Juvenile Delta Smelt Protections

Reclamation and DWR propose to protect larval and juvenile Delta smelt by changing operations when the flows in the western Delta, as measured by Q-West, are negative, and real-time Delta smelt monitoring indicates that Delta smelt larvae and juveniles are within the entrainment zone of the export pumps. The proposed action component will depend on hydrodynamic modeling that will estimate the percentage of the larval and juvenile smelt population that are at risk of entrainment, and operate to avoid a loss of no greater than ten percent of the population. The description of the proposed action component does not explain what actions will be taken, or to what degree exports will be modified, so our assessment of impacts on listed salmonids is qualitative.

Reductions in export pumping are typically beneficial to listed salmonids and sDPS green sturgeon and reduce the risk of entrainment and the alterations in routing and transit times associated with the effects of exports on local hydrodynamic conditions. During the period that actions would be taken to protect larval and juvenile Delta smelt (mid-March through June), actions to protect listed salmonids would most likely already be restricting the Old and Middle River flows to no more negative than -5,000 cfs.

8.6.9.2.17 Natural CCV Steelhead Protection

Reclamation and DWR propose under the proposed action (April 30, 2019; (U.S. Bureau of Reclamation 2019a)) to protect CCV steelhead by operating to an Old and Middle River flow of -2,500 cfs for five days whenever more than five percent of the annual population of CCV steelhead is determined to be in the Delta by the Delta specific working group and that the daily cumulative loss of natural (unclipped) steelhead at the CVP and SWP fish salvage facilities exceeds 10 fish per a thousand acre feet of water exported (10 fish/thousand acre-feet).

Reclamation and DWR intend for this proposed action component to protect San Joaquin River basin steelhead, but acknowledge that it is not feasible to discern which basin the observed CCV steelhead in salvage are coming from. This proposed action component will end on May 31 of each season.

Currently there is no assessment of when 5 percent of the population has entered the Delta, and no assessment of the size of the steelhead cohort each year to base it on. It is unclear how any new Delta specific working group will do this assessment due to the difficulty of monitoring for steelhead and their ability to avoid most monitoring gear. Furthermore, most CCV steelhead salvaged at the CVP and SWP fish salvage facilities are believed to be from the Sacramento River basin due to the greater population size originating in that basin. The San Joaquin River basin is believed to have a substantially smaller population size that would be overwhelmed by the signal generated by Sacramento River basin fish in salvage. The disparity in population sizes is just one factor making detection, and therefore protection of San Joaquin River basin fish difficult with this proposed action component. Another factor is the apparent differences in out migration timing. Sacramento River basin fish tend to emigrate earlier in the season than do San Joaquin River basin fish. Most Sacramento River basin CCV steelhead emigrate earlier in the season as indicated by the Sacramento trawl data (February and March, Figure 117) compared to the April and May period for the San Joaquin River basin population, and are likely the majority of CCV steelhead that are salvaged by the end of April (90 percent of salvage by May 1; Figure 118).

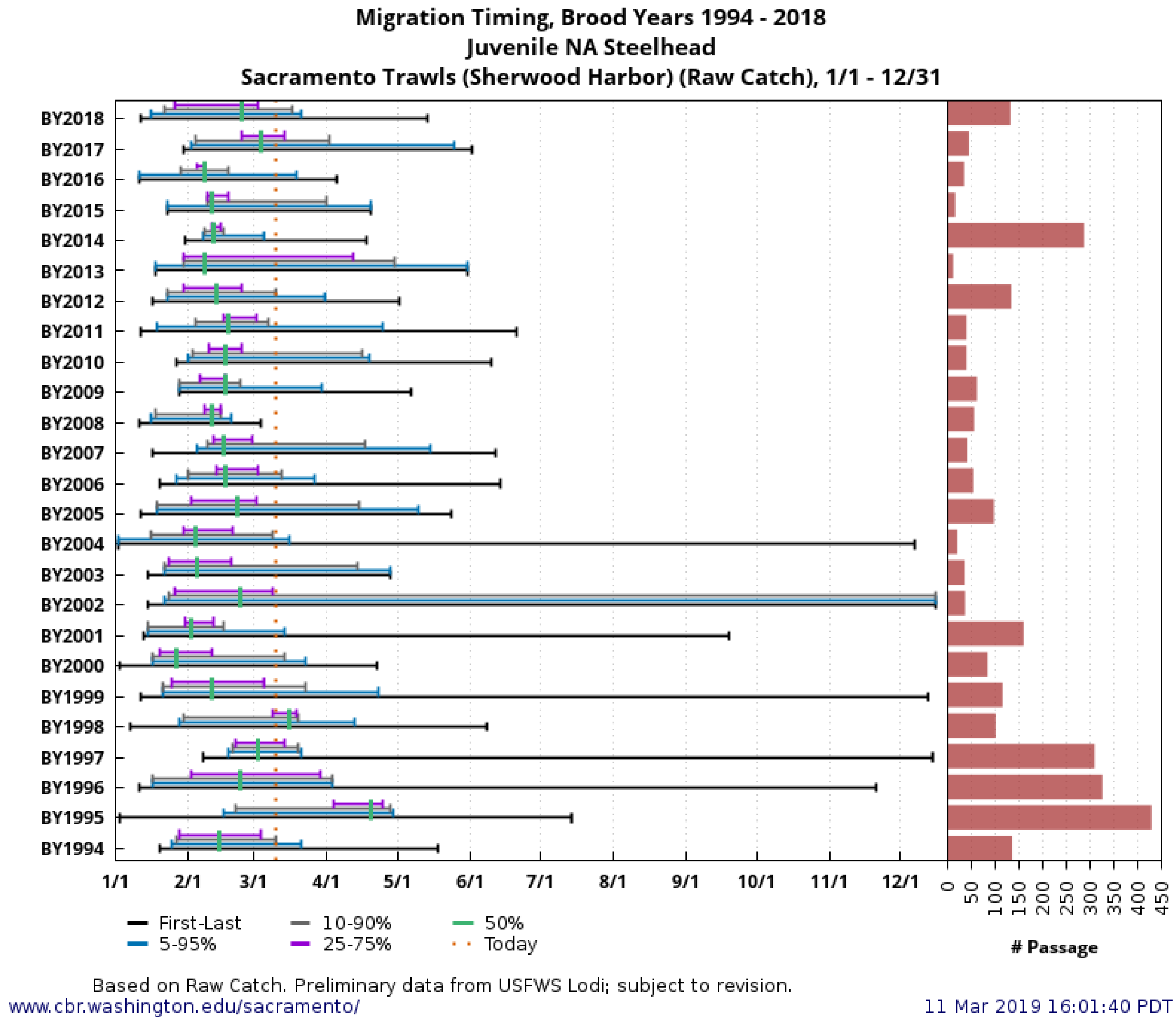


Figure 117. Juvenile unclipped California Central Valley steelhead migration timing past the Sherwood Harbor – Sacramento Trawl location for brood years 1994 to 2017.

It is unlikely that the size of the San Joaquin River basin CCV steelhead population would be sufficient to trigger the 10 steelhead/thousand acre-feet threshold that Reclamation and DWR are proposing. NMFS expects that in most instances when the loss density of natural CCV steelhead has exceeded the 10 fish/thousand acre-feet threshold that these fish belonged to the Sacramento River basin population and not to the San Joaquin River basin population. Currently export reductions are taken at two different levels of steelhead loss density; 8 fish/thousand acre-feet and 12 fish/thousand acre-feet. If the first level is exceeded, Old and Middle River is held at no more negative than -3,500 cfs for a minimum of 5 days. If the second level is exceeded, than Old and Middle River is held at no more negative than -2,500 cfs for a minimum of 5 days. Furthermore, NMFS assessed the frequency of steelhead loss density trigger exceedances since water year 2010 (the year that the RPA actions from the NMFS 2009 Opinion were first implemented) and found that incorporation of the proposed loss density trigger would reduce the implementation of Old and Middle River protective actions, based on steelhead loss density triggers, by 26 percent over all of the years in the period (2010-2018) and 46 percent in the years in which loss density triggers were actually exceeded (Table 103).

Table 103. Natural origin California Central Valley steelhead loss per thousand acre feet (TAF) for water years 2010 to 2018.

TAF	Water Year								
	2010	2011	2012	2013	2014	2015	2016	2017	2018
0 to <2	67	61	19	32	23	5	20	14	30
2 to <4	17	21	11	16	2	3	6	1	22
4 to <6	10	6	7	13	2	3	0	0	10
6 to <8	1	2	3	7	1	0	1	0	10
8 to <10	1	3	2	5	0	0	0	0	5
10 to <12	2	2	0	8	0	0	0	0	1
12 to <14	0	0	2	0	0	0	0	0	1
14 to <16	1	0	0	0	0	0	0	0	1
16 to <18	0	0	1	1	0	0	0	0	0
18 to <20	0	0	0	2	0	0	0	0	0
20 to <22				0					
22 to <24				0					
24 to <26				1					
26 to <28				0					
28 to <30				0					
30 to <32				1					
-	-	-	-	-	-	-	-	-	-
# > 8 fish/TAF	5	5	5	18	0	0	0	0	8
# > 10 fish/TAF	3	2	3	13	0	0	0	0	3
Difference	2	3	2	5	0	0	0	0	5
Change	40%	60%	40%	28%	0%	0%	0%	0%	63%
-	-	-	-	-	-	-	-	-	-
Average percent Change	26 percent reduction in the number of trigger exceedances (all water years 2010-2018) 46 percent reduction of trigger exceedances in water years with any exceedances								

In contrast, Old and Middle River flows in April and May are approximately 4,000 cfs more positive under the current operating scenario than the proposed action in wetter years. In drier years (below normal and dry water year types) the differences between the proposed action and current operating scenario were less, but were still approximately 1,500 cfs more positive under the current operating scenario conditions as compared to the proposed action conditions. In critical water year types, the current operating scenario was modeled to be 600 to 800 cfs more positive than the proposed action conditions. Seldom during the April and May period are modeled Old and Middle River flows predicted to be more positive/less negative under the proposed action than under the current operating scenario conditions, and positive Old and

Middle River flow values occur in April and May less frequently under the proposed action (<10 percent of years) compared to the current operating scenario (approximately 50 percent of years). During June, the proposed action is modeled as being more negative by 1,000 to 1,600 cfs in drier water year types (below normal, dry, and critical). Therefore, The current operating scenario is more protective of San Joaquin River basin CCV steelhead due to lower exports and more positive Old and Middle River flows than the proposed CCV steelhead loss density trigger.

Thus, the loss density trigger proposed by Reclamation and DWR is less protective of CCV steelhead in general and particularly for the populations originating in the San Joaquin River basin. The triggers will be dominated by CCV steelhead from the Sacramento River basin and typically occur earlier in the season when these fish are present in the Delta system. The higher threshold for the loss density trigger means that the implementation of the Old and Middle River protective actions will only occur about half as frequently (54 percent) as compared to the current protective actions implemented in the current operating scenario conditions. Since it is unlikely that any reductions in exports will occur due to the proposed loss density trigger for CCV steelhead, exports are likely to continue at a rate that manages to an Old and Middle River of no more negative than -5,000 cfs during the spring. It is unlikely that at the export rates typical of this Old and Middle River level, that any fish arriving at the export facilities via Old River will escape the influence of the exports, and will be entrained into the fish salvage facilities. Its survival is then linked to the efficiency of the fish salvage operations and the predator field in front of the fish salvage facilities.

8.6.9.2.18 Salvage or Loss Thresholds

Reclamation and DWR propose under the proposed action (April 30, 2019; (U.S. Bureau of Reclamation 2019a)) to set annual cumulative loss or salvage thresholds to modify export operations rather than the current real time actions under the current operating scenario related to the NMFS 2009 Opinion RPA actions (National Marine Fisheries Service 2009b). The proposed action component sets the winter-run Chinook salmon threshold as equal to loss of one percent of the annual winter-run juvenile production estimate for unclipped (natural) fish (genetically confirmed) or two percent of the juvenile production estimate if length-at-date identification is used. For unclipped CV spring-run Chinook salmon, a threshold of one percent loss of an annual spring-run juvenile production estimate (or a loss threshold of 0.5 percent of the yearling CV spring-run Chinook salmon surrogate releases -- late fall-run Chinook salmon from Coleman National Fish Hatchery) is proposed. NMFS assumes that the proposal would use the current methodology for calculating salvage and loss, based on expansion of observed salvaged fish and using the current loss multipliers. A threshold of 3,000 unclipped juvenile CCV steelhead in salvage is proposed for the proposed action. For green sturgeon, an annual salvage threshold of 100 fish is proposed. Reclamation and DWR intend to operate to -5000 cfs Old and Middle River flows until the annual cumulative loss or salvage reaches 50 percent of any of the threshold limits for a given species, at which point it will reduce exports and manage to an Old and Middle River limit of no more than -3,500 cfs on a 14-day moving average. If cumulative annual loss or salvage exceeds 75 percent of any annual threshold limit for a given species, then exports will be reduced to achieve an Old and Middle River flow of no more negative than -2,500 cfs on a 14-day moving average.

First, there is no CV spring-run Chinook salmon juvenile production estimate currently calculated that could serve as the basis for the proposed limit, so presumably the threshold based on the yearling CV spring-run Chinook salmon surrogate releases would be implemented until a CV spring-run Chinook salmon juvenile production estimate has been developed that would meet the objectives of this proposal. Secondly, based on historical salvage and loss data from the SWP and CVP facilities, it is unlikely that the 50 percent and 75 percent triggers would ever be exceeded. For unclipped winter-run Chinook salmon, the proposed 50 percent exceedance threshold (1 percent of juvenile production estimate using length-at-date criteria) occurred six times since 1992, but only twice since the implementation of the current operating scenario starting with brood year 2009. These most recent events occurred in two years when the juvenile production estimate was very low compared to other years. There are no proposed loss threshold triggers for hatchery produced winter-run Chinook salmon. This leaves hatchery winter-run Chinook salmon vulnerable to excessive entrainment. There is no CV spring-run Chinook salmon juvenile production estimate, as previously mentioned, so there is no historical reference of proportional take to guide the impacts of the implementation of the proposed limit. In regards to the proposed limits for unclipped CCV steelhead, the historical record for unclipped steelhead since 1998 when all hatchery-produced CCV steelhead began to be adipose fin-clipped, the annual salvage of unclipped CCV steelhead exceeded 1,500 fish seven times. However since brood year 2009 when the current operating scenario was implemented, the trigger threshold has not been exceeded (Table 104). Since 2000, the annual salvage of sDPS green sturgeon has been less than 100 fish in any given year except for 2006, when 363 green sturgeon were salvaged. In recent years since 2010, only twice have sDPS green sturgeon been salvaged, and both times it was for a total of 4 fish annually, substantially below the 50 percent threshold of 50 fish required to initiate any export reductions to manage Old and Middle River flows.

Table 104. Estimated monthly adjusted loss of Central Valley spring-run Chinook salmon for all water year types combined based on the salvage-density method.

Month	Predicted loss under current operating scenario (COS)	Predicted loss under proposed action (PA)	PA-COS	Change
October	0	0	0	--
November	0	0	0	--
December	0	0	0	--
January	0	0	0	--
February	5	5	0	--
March	191	181	-9	-5%
April	437	1,062	625	143%
May	207	473	266	128%
June	11	10	1	-2%
July	0	0	0	--
August	0	0	0	--
September	0	0	0	--

Based on the above information, it is unlikely that the thresholds proposed by Reclamation and DWR will be exceeded, except on rare occasion. Thus, reductions in exports and changes to make Old and Middle River more positive are unlikely to occur and the Old and Middle River flows will stay at -5000 cfs for the entire period of implementation of Old and Middle River flow management (January 1 through late spring). This is less protective than the current current operating scenario conditions which provide substantial export reductions in the April and May periods to protect San Joaquin River basin CCV steelhead. Furthermore, the proposed Old and Middle River flow management actions do not include real-time reductions based on daily trigger thresholds in the NMFS 2009 Opinion for RPA Action IV.2.3 (National Marine Fisheries Service 2009b). This places an additional risk on listed fish populations that are already experiencing difficult conditions in the Delta and have low overall population viability.

8.6.9.2.19 Storm-Related Old and Middle River Flexibility

Reclamation and DWR are also proposing to incorporate storm-related flexibility in Old and Middle River flow management by proposing combined exports to increase up to potentially full capacity (14,900 cfs) to capture any excess water in the Delta system that is available through storm-related increases in river inflows and export that water south of the Delta. The full description of the proposed action component is provided in Section 8.6.9 “Old and Middle River Flow Management.” Storm-related increases in exports will not be allowed if any of the previous additional real-time Old and Middle River restrictions already discussed are triggered, and in that case, Reclamation would operate in accordance with those additional real-time Old and Middle River restrictions and would not cause Old and Middle River to be more negative for capturing peak flows from storm-related events.

The proposed action component also includes measures to off ramp from the storm flex exports if natural winter-run Chinook salmon are entrained and their calculated loss exceeds the percentages of cumulative loss thresholds tied to the annual juvenile production estimate provided in Section 8.6.9. These percentages increase with the progression into the winter-run Chinook salmon migratory season and extend through the end of the Old and Middle River flow management period.

The salmonid scoping team (Management Question #3 in Volume 2, 2017b) summarized the conceptual model for export-related effects on salmonids as follows:

> *“Export effects that incrementally increase the routing of juvenile salmonids (either from the Sacramento River or from the San Joaquin River) into the Interior Delta will incrementally reduce overall survival…In addition to the predicted effects of export on routing, the conceptual model predicts that Old and Middle River reverse flow management will decrease mortality by increasing the probability that juveniles that enter the South Delta (San Joaquin River mainstem and channels to the south and west of the San Joaquin River mainstem) will successfully migrate out of the South Delta to Chipps Island. Mechanisms by which this might occur include: 1) reducing entrainment at the export facilities…; 2) reducing confusing navigational cues caused by Old and Middle River reverse flow; and 3) increasing the duration and magnitude of ebb tide flows and velocities, relative to flood tides, which is expected to reduce the residence time of juveniles in the South Delta and, therefore, reduce exposure time to agents of mortality.”*

Key conclusions in the salmonid scoping team report were:

- For junctions on both the Sacramento River and San Joaquin River, "…a -5,000 cfs Old and Middle River reverse flow limit provides protection compared to more negative Old and Middle River reverse flow levels that would exert a larger influence on flow routing at distributary junctions and, thus, on juvenile routing and survival." However, the salmonid scoping team "did not conclude at what precise level of Old and Middle River flow more negative than -5,000 cfs exports would begin to affect distributary flows, juvenile routing, and survival", and also noted some technical disagreement on this point.
- Within the interior channels of the South Delta, "…the -5,000 cfs Old and Middle River flow is predicted to be less effective at preventing or minimizing export effects on juvenile routing at junctions and residence times within the interior channels of the South Delta than in the mainstems of the Sacramento River and San Joaquin River…because the export-driven influence on hydrodynamic conditions at a given Old and Middle River flow level increase with proximity to the export facilities.
- The salmonid scoping team noted that there is "inadequate empirical evidence from fish tracking studies to more precisely evaluate junction-specific relationship between distributary flow changes and changes in fish routing and survival. As a results there is uncertainty in relating specific Old and Middle River reverse flow thresholds to overall through-Delta survival.
- The salmonid scoping team concluded that "…route selection is generally proportional to the flow split at channel junctions, and the effect of exports on route selection is strongest at the junction leading directly to the export facilities (i.e., head of Old River)."

We can evaluate some of the conceptual model mechanisms described above based on modeling provided in the ROC on LTO biological assessment. The salvage density modeling shows that salvage and associated loss increases with exports during months when listed salmonids are present in the Delta. Therefore, if fish are present in the vicinity of the export facilities in the south Delta during a time that storm flex export operations are implemented, NMFS concludes there will be an increase in the number of fish entrained into the salvage facilities above that which would have been seen with no increases in exports. Furthermore, since listed salmonids tend to start migrating downstream in response to elevated flows in the Sacramento River basin and San Joaquin River basin waterways, there is a high probability that more fish will be present in the Delta exactly when the CVP and SWP increase their exports. Besides the fish entering the Delta on the elevated storm flows, listed salmonids (especially winter-run Chinook salmon) may already be present in the Delta due to migration earlier in the year. This overlap in fish presence and the potential for combined exports to reach 14,900 cfs can result in increased entrainment risk as a result of the potentially very negative Old and Middle River flows. Reclamation has committed to a risk assessment before implementing a storm flex export operation which could limit risks. Salmonid Scoping Team (2017a) concluded that "…route selection is generally proportional to the flow split at channel junctions, and the effect of exports on route selection is strongest at the junction leading directly to the export facilities (i.e., Head of Old River)." Any fish that originates in the San Joaquin River basin will be at a high risk of entrainment due to the routing of fish through Old River from the Head of Old River. The fish that stay within the main stem San Joaquin River channel at the head of Old River may enter the interior Delta at other junctions and be exposed to the increased foot print of the altered hydrodynamics created by the high level of exports in the channels leading to the pumps. Triggers based on loss density for unclipped steelhead are less likely to happen under the high export condition as greater volumes of water are present to be diverted, compared to the number of fish present to be entrained in the surrounding waterways.

The hydraulic conditions created by the high export rates have a high probability of creating more adverse conditions in the south Delta waterways than are currently observed for migrating fish. The severity will depend on which basin has the high storm flows and to what extent the exports are increased. Assuming the worst case scenario, combined exports of 14,900 cfs, with flows originating only in the Sacramento River basin, the footprint of the export effects will encompass much of the south and central Delta up to and including the main stem San Joaquin River downstream to at least Jersey Point. If the storms are present only in the Sacramento River basin and river flows are increased only for that basin, then elevated exports will exaggerate the effects of Old and Middle River as water is predominately coming from the north across the Delta to supply the high exports. Low flows in the San Joaquin River basin at the same time would exacerbate this condition, as they would not offset the source of export water being diverted by the pumps. Conversely, if storms are centered over the San Joaquin River basin and high delta inflows are confined to the main stem of the San Joaquin River, the high export rates will pull in mostly water from this source. Flow through Old River via the Head of Old River will offset the effects of exports on Old and Middle River flows to some extent, depending on the magnitude of combined exports, and the volume of flow coming through the Head of Old River. Because there is less unregulated flow in the San Joaquin River compared to the Sacramento River, "storm" events that trigger an Old and Middle River storm flex are more likely to be dominated by Sacramento River flow.

8.6.9.2.20 Revisions to Old and Middle River Management

As a result of discussions, the Old and Middle River management section of the proposed action included sufficient changes and that the final proposed action (U.S. Bureau of Reclamation 2019b) shows most of the proposed action component as new text – not changes relative to the February 5, 2019 proposed action. All details of the revised Old and Middle River Management component of the proposed action are excerpted below; bold, italicized, text is used to highlight key changes assessed in this supplemental analysis.

Onset of Old and Middle River Management:

"Reclamation and DWR shall start Old and Middle River management when one or more of the following conditions have occurred:

- Integrated Early Winter Pulse Protection ("First Flush" Turbidity Event): To minimize project influence on migration (or dispersal) of Delta Smelt, Reclamation and DWR proposes to reduce exports for 14 consecutive days so that the 14-day averaged Old and Middle River index for the period shall not be more negative than ***-2,000 cfs,*** in response to "First Flush" conditions in the Delta. The population-scale migration of Delta Smelt is believed to occur quickly in response to inflowing freshwater and turbidity (Grimaldo et al. 2009; Sommer et al. 2011). Thereafter, the best available scientific information suggests that fish make local movements, but there is no evidence for further population-scale migration (Polansky et al. 2017). "First Flush" conditions may be triggered between December 1 and January 31 and include:

- running 3-day average of the daily flows at Freeport is greater than 25,000 cfs and
- running 3-day average of the daily turbidity at Freeport is 50 NTU or greater, or
- real-time monitoring indicates a high risk of migration and dispersal into areas at high risk of future entrainment.

This "First Flush" action may only be initiated once during the December through January period and will not be required if:

- water temperature reaches 12 °C (53.6°F) based on a three station daily mean at Honker Bay, Antioch, and Rio Vista, and/or
- ripe or spent Delta Smelt are collected in monitoring surveys.

Salmonids Presence: After January 1, if more than 5 percent of any one or more salmonid species (natural origin young-of-year Winter-Run, natural origin young-of-year Spring-Run, or natural origin Central Valley Steelhead) are estimated to be present in the Delta as determined by their appropriate monitoring working group based on available real-time data, historical information, and modeling."

Additional Real-Time Old and Middle River Restrictions and Performance Objectives:

"Reclamation and DWR shall manage to a more positive Old and Middle River than -5,000 cfs based on the following conditions:

- Turbidity Bridge Avoidance ("South Delta Turbidity"): After the Integrated Early Winter Pulse Protection (above) or February 1, whichever comes first, and prior to April 1, Reclamation and DWR propose to manage exports in order to maintain daily average turbidity in Old River at Bacon Island at a level of less than 12 NTU. The purpose of this action is to protect Delta Smelt from damaging levels of entrainment after a First Flush and in years when a First Flush does not occur. This action seeks to avoid the formation of a continuous turbidity bridge from the San Joaquin River shipping channel to the fish facilities, which historically has been associated with elevated salvage of pre-spawning adult Delta Smelt. If the day daily average turbidity at Bacon Island cannot be maintained less than 12 NTU, Reclamation and DWR will manage exports to achieve an Old and Middle River no more negative than ***-2,000 cfs*** until the turbidity at Bacon Island drops below 12 NTU. After 5 days, Reclamation and DWR may determine that additional real-time Old and Middle River restrictions are not required to avoid damaging levels of entrainment based on the distribution of Delta Smelt in real-time monitoring and the absence of detections in salvage (i.e. <5 percent of the population).
- Larval and Juvenile Delta Smelt: When Q-West is negative and larval or juvenile Delta Smelt are within the entrainment zone of the pumps based on real-time sampling, Reclamation and/or DWR propose to run hydrodynamic models informed by the EDSM, 20 mm or other relevant survey data to estimate the percentage of larval and juvenile Delta Smelt that could be entrained and operate to avoid greater than 10 percent loss of modeled larval and juvenile cohort Delta Smelt (typically this would come into effect beginning the middle of March).

Cumulative Loss Threshold:

Reclamation and DWR propose to avoid exceeding cumulative loss thresholds over the duration of the Biological Opinions for natural origin Winter-Run Chinook Salmon, hatchery Winter-Run

Chinook Salmon, natural origin Central Valley Steelhead from December through March, and natural origin Central Valley Steelhead from April 1 through June 15th. Natural origin Central Valley Steelhead are separated into two time periods to protect San Joaquin Origin fish that historically appear in the Mossdale trawls later than Sacramento origin fish. The loss threshold and loss tracking for hatchery Winter-Run Chinook Salmon does not include releases into Battle Creek. Loss (for development of thresholds and ongoing tracking) for Chinook salmon are based on length-at-date criteria.

The cumulative loss thresholds shall be based on cumulative historical loss from 2010 through 2018. Reclamation's and DWR's performance objectives will set a trajectory such that this cumulative loss threshold (measured as the 2010-2018 average cumulative loss multiplied by 10 years) will not be exceeded by 2030.

If, at any time prior to 2024, Reclamation and DWR exceed 50 percent of the cumulative loss threshold, Reclamation and DWR will convene an independent panel to review the actions contributing to this loss trajectory and make recommendations on modifications or additional actions to stay within the cumulative loss threshold, if any.

In the year 2024, Reclamation and DWR will convene an independent panel to review the first five years of actions and determine whether continuing these actions are likely to reliably maintain the trajectory associated with this performance objective for the duration of the period.

If, during real-time operations, Reclamation and DWR exceed the cumulative loss threshold, Reclamation and DWR would immediately seek technical assistance from FWS and NMFS, as appropriate, on the coordinated operation of the CVP and SWP for the remainder of the Old and Middle River management period. In addition, Reclamation and DWR shall, prior to the next Old and Middle River management season, charter an independent panel to review the Old and Middle River Management Action consistent with "Chartering of Independent Panels" under the "Governance" section of this Proposed Action. The purpose of the independent review shall be to evaluate the efficacy of actions to reduce the adverse effects on listed species under Old and Middle River management and the non-flow measures to improve survival in the south Delta and for San Joaquin origin fish.

Single-Year Loss Threshold:

In each year, Reclamation and DWR propose to avoid exceeding an annual loss threshold equal to 90 percent of the greatest annual loss that occurred in the historical record from 2010 through 2018 for each of natural origin Winter-Run Chinook Salmon, hatchery Winter-Run Chinook Salmon, natural origin Central Valley Steelhead from December through March, and natural origin Central Valley Steelhead from April through June 15. Natural origin Central Valley Steelhead are separated into two time periods to protect San Joaquin Origin fish that historically appear in the Mossdale trawls later than Sacramento origin fish. The loss threshold and loss tracking for hatchery Winter-Run Chinook Salmon does not include releases into Battle Creek. Loss (for development of thresholds and ongoing tracking) for Chinook salmon are based on length-at-date criteria.

During the year, if Reclamation and DWR exceed the average annual loss from 2010 through 2018, Reclamation and DWR will review recent fish distribution information and operations with the fisheries agencies at water operations management team and seek technical assistance on future planned operations. Any agency may elevate from water operations management team to a Directors discussion, as appropriate.

During the year, if Reclamation and DWR exceed 50 percent of the annual loss threshold, Reclamation and DWR will restrict Old and Middle River to a 14-day moving average Old and Middle River index of no more negative than -3,500 cfs for the rest of the season for that species. Reclamation and DWR will seek NMFS technical assistance on the risk assessment and real-time operations.

Reclamation and DWR determine that further Old and Middle River restrictions are not required to benefit fish movement because a risk assessment shows that the risk is no longer present based on real-time information.

During the year, if Reclamation and DWR exceed 75 percent of the annual loss threshold, Reclamation and DWR will restrict Old and Middle River to a 14-day moving average Old and Middle River index of no more negative than -2,500 cfs for the rest of the season. Reclamation and DWR will seek NMFS technical assistance on the risk assessment and real-time operations.

Reclamation and DWR determine that further Old and Middle River restrictions are not required to benefit fish movement because a risk assessment shows that the risk is no longer present based on real-time information.

Risk assessment: Reclamation and DWR will determine and adjust Old and Middle River restrictions under this section by preparing a risk assessment that considers several factors including, but not limited to, real-time monitoring detects few fish in the south Delta and few fish are detected in salvage. Reclamation and DWR will share its technical analysis and supporting documentation with FWS and NMFS, seek their technical assistance, discuss the risk assessment and future operations with water operations management team at its next meeting, and elevate to the Directors as appropriate.

If, during real-time operations, Reclamation and DWR exceed the single-year loss threshold, Reclamation and DWR would immediately seek technical assistance from FWS and NMFS, as appropriate, on the coordinated operation of the CVP and SWP for the remainder of the Old and Middle River management period. In addition, Reclamation and DWR shall, prior to the next Old and Middle River management season, charter an independent panel to review the Old and Middle River Management Action consistent with "Chartering of Independent Panels" under the "Governance" section of this Proposed Action. The purpose of the independent review shall be to evaluate the efficacy of actions to reduce the adverse effects on listed species under Old and Middle River management and the non-flow measures to improve survival in the south Delta and for San Joaquin origin fish.

Reclamation and DWR shall consider the historical monthly distribution of loss to avoid disproportionately salvaging fish during any single month.

Reclamation and DWR propose to continue monitoring and reporting the salvage at the Tracy Fish Collection Facility and Skinner Delta Fish Protective Facility. Reclamation and DWR propose to continue the release and monitoring of yearling Coleman NFH late-fall run as yearling Spring-Run Chinook Salmon surrogates."

Storm-Related Old and Middle River Flexibility:

"Reclamation and DWR may operate to a more negative Old and Middle River up to a maximum (otherwise permitted) export rate at Banks and Jones Pumping Plants of 14,900 cfs (which could result in a range of Old and Middle River values) to capture peak flows during storm-related events. Reclamation and DWR will continue to monitor fish in real-time and will operate in accordance with "Additional Real- time Old and Middle River Restrictions," above. Under the following conditions, Reclamation and DWR would not cause Old and Middle River to be more negative for capturing peak flows from storm-related events if:

- Integrated Early Winter Pulse Protection (above) or Additional real-time Old and Middle River restrictions (above) are triggered. Under such conditions, Reclamation and DWR have already determined that more restrictive Old and Middle River is required.
- An evaluation of environmental and biological conditions indicates more negative Old and Middle River would likely cause Reclamation and DWR to trigger an Additional real-time Old and Middle River restriction (above).
- Salvage of yearling Coleman NFH latefall run as yearling Spring-Run Chinook Salmon surrogates exceeds 0.5 percent within any of the release groups.
- Reclamation and DWR identify changes in spawning, rearing, foraging, sheltering, or migration behavior beyond those described in the forthcoming biological opinion for this project.

Reclamation and DWR will continue to monitor conditions may resume management of Old and Middle River to no more negative than -5,000 cfs if conditions indicate the above offramps are necessary to avoid additional adverse effects. If storm-related flexibility causes the conditions in "Additional Real-Time Old and Middle River Restrictions", Reclamation and DWR will implement additional real-time Old and Middle River restrictions."

End of Old and Middle River Management:

"Old and Middle River criteria may control operations until June 30 (for Delta Smelt and Chinook salmon), ***until June 15 (for steelhead/rainbow trout)***, or when the following species-specific off ramps have occurred, whichever is earlier:

- Delta Smelt: when the daily mean water temperature at Clifton Court Forebay reaches 25°C for 3 consecutive days;
- Salmonids:
    - when more than 95 percent of salmonids have migrated past Chipps Island, as determined by their monitoring working group, or
    - after daily average water temperatures at Mossdale exceed 72°F for 7 days during June (the 7 days do not have to be consecutive)."

Real-Time Decision Making and Salvage Thresholds

"Reclamation and DWR may confer with the Directors of NMFS, FWS, and CDFW if they desire to operate to a more negative Old and Middle River than what is specified in 'Additional Real-Time Old and Middle River Restrictions.' Upon mutual agreement, the Directors of NMFS and FWS may authorize Reclamation to operate to a more negative Old and Middle River than the 'Additional Real-Time Old and Middle River Restrictions', but no more negative than -5000 cfs. The Director of CDFW may authorize DWR to operate to a more negative Old and Middle

River than the ‘Additional Real-Time Old and Middle River Restrictions’, but no more negative than -5000 cfs.”

The specific cumulative and single-year loss thresholds are described in detail in Appendix I and summary figures are provided showing historical loss and associated loss thresholds for natural origin winter-run Chinook salmon (Figure 118), hatchery winter-run Chinook salmon (Figure 119) and natural origin steelhead (Figure 120 and Figure 121).

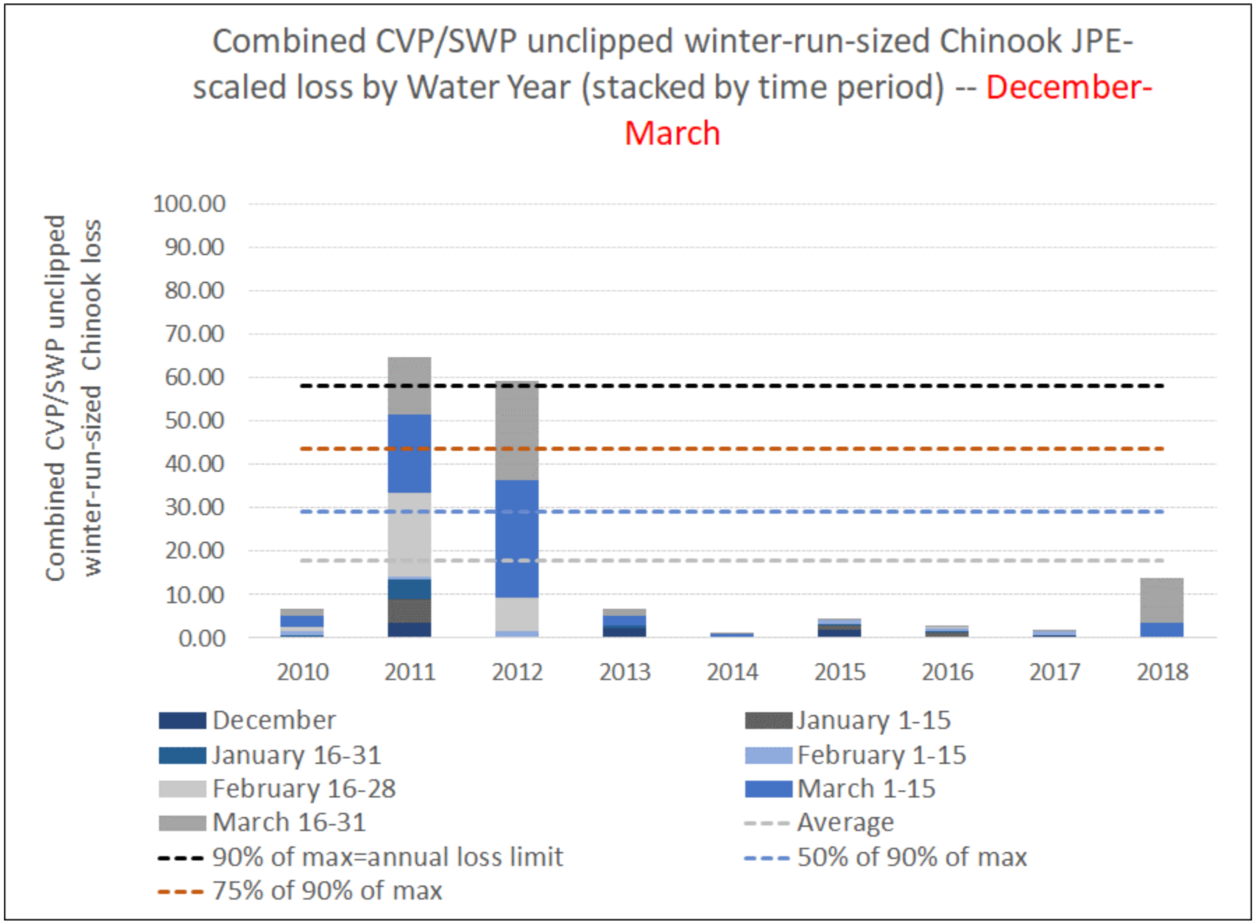


Figure 118. Combined unclipped winter-run-sized Chinook loss, as a percentage of the winter-run Juvenile Production Estimate, for water WY 2010 through WY 2018.

Bars represent cumulative loss from December through March, stacked by month. Horizontal reference lines indicate the loss thresholds relevant for Old and Middle River management.

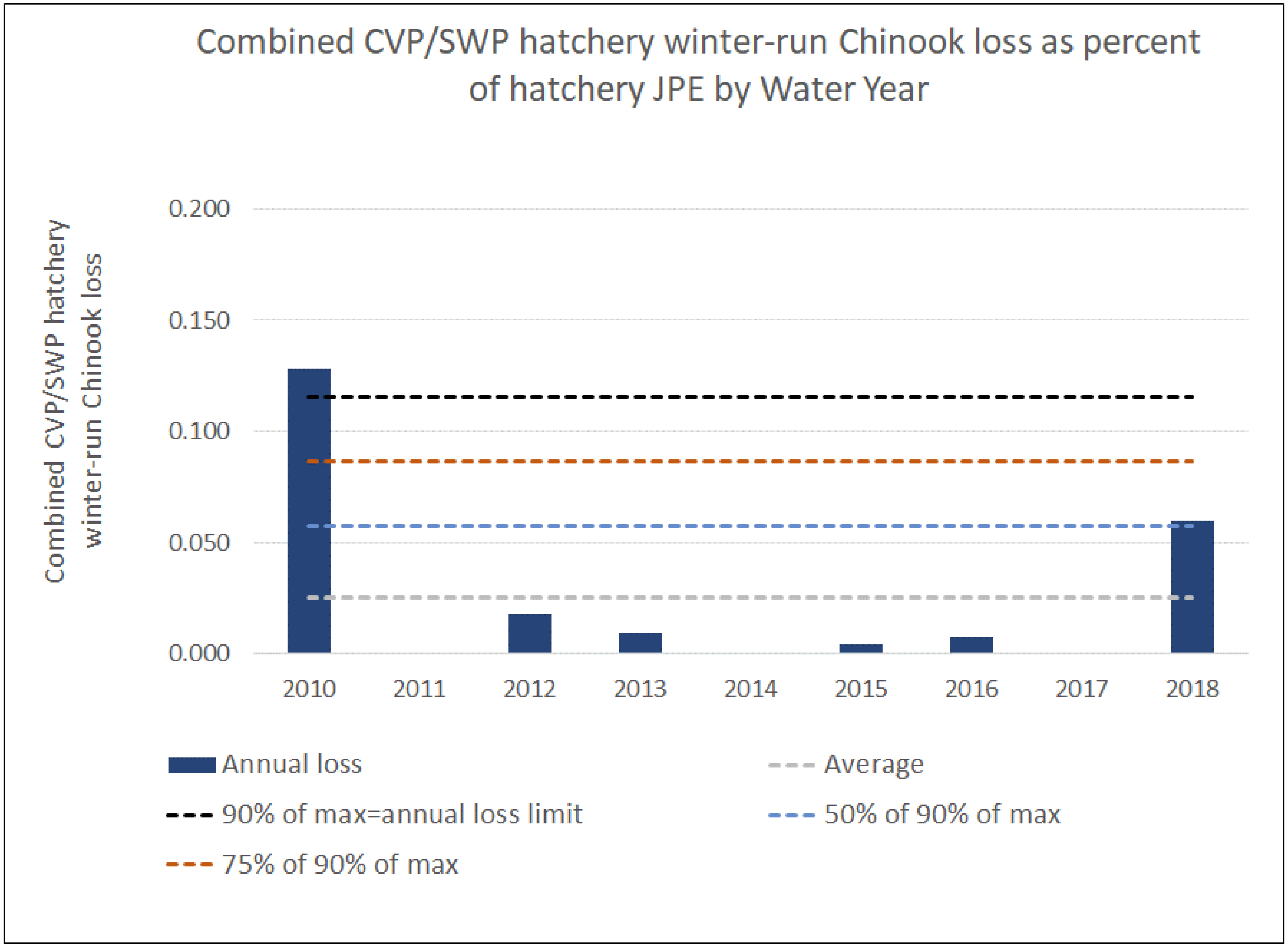


Figure 119. Combined CVP/SWP hatchery winter-run Chinook loss for WY 2010 through WY 2018, as a percent of the number released into the Sacramento River.

Bars represent cumulative loss observed within the water year of release. Horizontal reference lines indicate the loss thresholds relevant for Old and Middle River management.

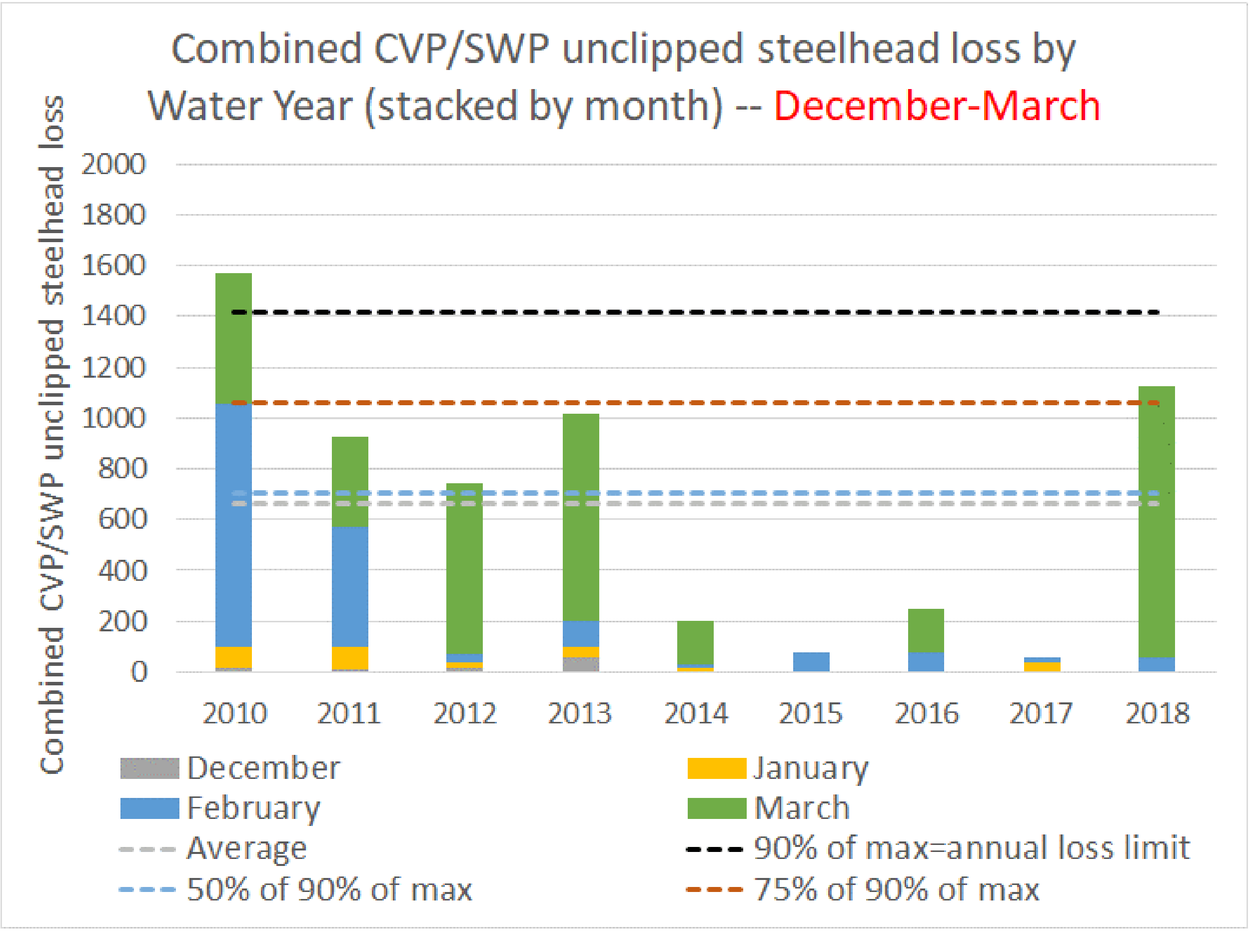


Figure 120. Combined CVP/SWP natural origin steelhead loss for water years 2010 to 2018. Bars represent cumulative loss from December through March, stacked by month. Horizontal reference lines indicate the loss thresholds relevant for Old and Middle River management.

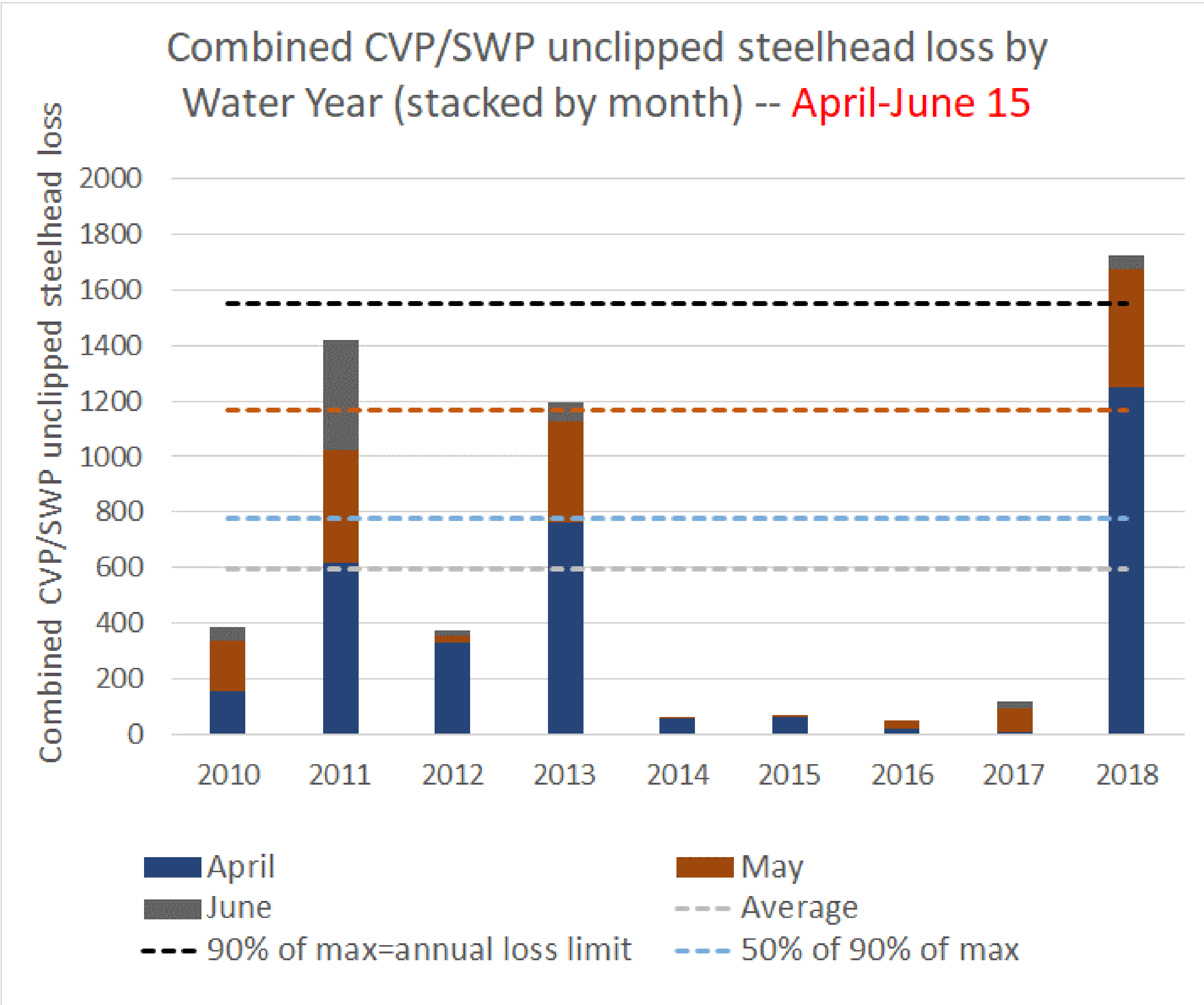


Figure 121. Combined CVP/SWP natural origin steelhead loss for WY 2010 through WY 2018. Bars represent cumulative loss from April through June 15, stacked by month. Horizontal reference lines indicate the loss thresholds relevant for Old and Middle River management.

8.6.9.2.21 Assess Exposure to Species from Revised Old and Middle River Management

The revised Old and Middle River management component in the final proposed action (and any associated changes in exports) will not affect overall seasonal presence of listed salmonids and sDPS green sturgeon in the Delta.

There is interannual variability in loss rates observed for natural origin and hatchery winter-run Chinook salmon, and natural origin CCV steelhead. Some of this variability is likely due to interannual variability in population size, but note that variability is observed even for natural origin winter-run Chinook salmon after scaling to estimated 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 thresholds is designed to accommodate this interannual variability while controlling for long-term loss.

8.6.9.2.22 Assess Response to Species from Revised Old and Middle River Management

NMFS's approach to linking hydrodynamics with species responses is described earlier in the Delta effects section. So, to understand the species responses, NMFS first assesses the likely difference in hydrodynamic conditions under the final proposed action compared to the original proposed action. It is uncertain how exactly exports and Old and Middle River flows under the final proposed action will change in a given month and year type compared to the original proposed action, but NMFS makes the following assumptions for this supplemental analysis.

- The changes to the turbidity-related Old and Middle River triggers likely have little to no effect on our analysis, since the Old and Middle River limits in the final proposed action are consistent with the modeling assumptions used for the modeling provided with the original biological assessment.
- The removal of the 10 steelhead/thousand acre-feet loss trigger may reduce the frequency of short-term "pulse protection" at a -2,500 cfs Old and Middle River limit for steelhead, but in our original analysis (in the previous sections), NMFS expressed concern that this protective action would rarely be triggered, so the loss of a rarely-triggered protective action does not substantively change our analysis.
- The other interim loss thresholds (50 percent and 75 percent of the annual loss limit of 90 percent of maximum historical loss) are also "yellow lights" that are associated with even more formal risk assessment and discussion.
- The cumulative and single-year loss thresholds are lower in the proposed action, and thus the interim thresholds at 50 percent and 75 percent of the annual loss threshold are more likely to be reached and a potential Old and Middle River action response considered.
- When 50 percent or 75 percent of a loss threshold is reached, operations under the final proposed action are less certain to result in a more positive Old and Middle River than under the original proposed action. While the action response in the final proposed action is contingent on the conclusion of Reclamation's and DWR's risk assessment, the action

response will occur "unless Reclamation and DWR determine that further Old and Middle River restrictions are not required to benefit fish movement because a risk assessment shows that the risk is no longer present based on real-time information." Additionally, the risk assessment will undergo inter-agency review, since "Reclamation and DWR will share its technical analysis and supporting documentation with FWS and NMFS, seek their technical assistance, discuss the risk assessment and future operations with water operations management team at its next meeting, and elevate to the Directors as appropriate." So, while it is not certain whether Old and Middle River limits more positive than -5,000 cfs are more or less likely under the final proposed action, the multiple process steps in the final proposed action provide some assurance that species risks will be conservatively managed.

- Change in the date-based offramp criterion for steelhead from June 30 to June 15 means that, if Old and Middle River management is not in effect for another species, Old and Middle River management might end up to two weeks sooner for steelhead, potentially exposing steelhead migrating through the Delta in late June to hydrodynamic conditions less suited for successful outmigration.

8.6.9.2.23 Assess Risk to Species from Revised Old and Middle River Management

The cumulative and single-year loss thresholds were developed to avoid loss for key (and reliably measurable) populations greater than loss rates observed under the NMFS 2009 Opinion. The intent of these proposed action revisions was to reduce and limit loss through the Additional Real-Time Old and Middle River Restrictions in place between the Onset of Old and Middle River Management and End of Old and Middle River Management. These proposed action revisions limit direct loss at the south Delta export facilities as a way to avoid higher magnitude direct effects associated from increased exports between the onset and end of Old and Middle River management (based on environmental conditions and real-time fish monitoring) and other areas of uncertainties previously analyzed in this Opinion to what was observed from 2010-2018 under the NMFS 2009 Opinion. The proposal uses a combination of Old and Middle River management and a metric of historical loss rates to keep risks comparable to risks under the NMFS 2009 Opinion. NMFS concludes 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, the final proposed action includes triggers for review and technical assistance anytime observed loss exceeds average annual historical loss, which provide 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. It is likely that Old and Middle River (and associated Delta hydrodynamics) may still be more negative under the final proposed action than observed under the current operating scenario, especially in April and May. Under the current operating scenario, the Old and Middle River exceedance plots show that April - May Old and Middle River is positive for approximately 60 percent of years, and under the initial proposed action (without these performance objectives) the frequency of positive flows decreases to less than ten percent. NMFS acknowledges that, in most years, especially in drier years, other factors may control Old and Middle River and lead to Old and Middle River flows more positive than the Old and Middle River limits associated with the loss thresholds of the final proposed action. For example, the modeling even for the original biological assessment showed that April Old and Middle River flows under the original proposed action during critical years were about -1,500 cfs and during wet years were about -900 cfs. The modeled Old and Middle River averages are more positive than -2,500 cfs for April and May (averaged over all water year types). Regardless of water year type, May average Old and Middle River are always more negative than April average Old and Middle River estimates, but neither months average Old and Middle River values are more negative as -3,500cfs (biological assessment, Appendix D). NMFS expects these values would become more positive in some years with the final proposed action.

While loss is expected to occur under the final proposed action, NMFS notes that the loss thresholds are expected to limit loss to levels less than what has been observed during the 2009 NMFS Biological Opinion. Estimated loss using the Salvage Density Model results showed the greatest differences in the proposed action vs. the current operating scenario during April and May, and NMFS expects that the benefits of the revised loss thresholds (relative to the proposed action) will be greatest during this April-May period during outmigration of CCV steelhead (particularly from the San Joaquin basin) and young-of-year CV spring-run Chinook salmon. An evaluation of observed loss during the 2010 to 2018 period describes the potential occurrence of cumulative and single-year loss threshold exceedances assuming similar hydrological and fishery conditions.

For winter-run Chinook salmon, the average loss threshold was exceeded in two out of nine years, which would have led to Reclamation and DWR seeking technical assistance on future planned operations and led to operational and fisheries reviews by water operations management team. The 50 percent and 75 percent annual loss thresholds were both exceeded during both of these two years, which would resulted in reductions to Old and Middle River no more negative than -3,500 cfs then -2,500 cfs until the risk was no longer present based on real-time information. The 50 percent cumulative loss threshold was also exceeded in both of these years, which would have led to review panels focused on how Old and Middle River management contributed to the loss trajectory and recommendations on modification or additional actions to stay within the cumulative loss threshold. Based on the proposed action description, Reclamation will consider and implement as appropriate.

For hatchery winter-run salmon, the average loss threshold was exceeded in two out of nine years, which would have led to Reclamation and DWR seeking technical assistance on future planned operations and led to operational and fisheries reviews by water operations management team. The 50 percent loss threshold was exceeded in two out of nine years resulting in reductions to Old and Middle River no more negative than -3,500 cfs until the risk was no longer present based on real-time information. In one of these exceedance years, further Old and Middle River reductions to -2,500 cfs would have occurred since the 75 percent loss threshold was exceeded until the risk was no longer present based on real-time information.

For steelhead during December 1 through March 30, the average loss threshold was exceeded in 5 out of 9 years, which would have led to Reclamation and DWR seeking in-season technical assistance on future planned operations and led to operational and fisheries reviews by water operations management team. The 50 percent loss threshold was also exceeded in these five years resulting in reductions to Old and Middle River no more negative than -3,500 cfs until the risk was no longer present based on real-time information. Out of these five year, the 75 percent loss threshold was exceeded in two years, which would have resulted in reductions to Old and Middle River no more negative than -2,500 cfs until the risk was no longer present based on real-time information. Also, the single-year annual loss limit was exceeded once in nine years which would have required Reclamation and DWR to immediately seek technical assistance from FWS and NMFS on the coordinated operations of the CVP and SWP for the remainder of the Old and Middle River management period and review of the Old and Middle River management period by an independent review panel.

For steelhead during April 1 to June 15, the average loss threshold was exceeded in 3 out of 9 years, which would have led to Reclamation and DWR seeking technical assistance on future planned operations and operational and fisheries reviews by water operations management team. The 50 percent and 75 percent loss threshold was also exceeded during these 3 years, which would have resulted in the Old and Middle River management season including periods (until the risk was no longer present based on real-time information) with reductions to Old and Middle River no more negative than -3,500 cfs and -2,500 cfs, respectively.

8.6.9.2.24 Revisions to Old and Middle River Management

Table 105. Changes to the Old and Middle River management made during consultation.

Element	February 5, 2019 (original) proposed action	September 19, 2019 (final) proposed action
Onset of Old and Middle River Management		
Old and Middle River limit associated with "First Flush" Turbidity event	-3,500 cfs (PA text) -2,000 cfs (PA Modeling in Appendix D of biological assessment)	-2,000 (PA text) *No new modeling.*
Additional Real-Time Old and Middle River Restrictions		
Old and Middle River limit associated with Turbidity Bridge Avoidance	-5,000 cfs (PA text) -2,000 cfs (PA Modeling in Appendix D of biological assessment)	-2,000 cfs (PA text) *No new modeling.*
Natural origin Central Valley Steelhead Protection	Old and Middle River limit of -2,500 cfs for 5 days whenever more than 5 percent of steelhead are present in the Delta and daily loss of natural origin steelhead exceeds 10 steelhead per thousand acre-feet.	No daily loss trigger; replaced with revised steelhead loss threshold.
Loss threshold (cumulative): for specified populations	None identified	Cumulative historical loss from 2010-2018 (measured as the 2010-2018 average cumulative loss multiplied by 10 years) will not be exceeded by 2030.

Element	February 5, 2019 (original) proposed action	September 19, 2019 (final) proposed action
Salvage or Loss Thresholds (annual): Natural origin winter-run Chinook salmon (loss)	1 percent of the juvenile production estimate (genetically confirmed or 2 percent based on length at date)	90 percent of the greatest annual loss that occurred in the historical record from 2010 through 2018 (December-March): 1.17 percent of the juvenile production estimate
Salvage or Loss Thresholds (annual): spring-run Chinook salmon (loss)	1 percent of the juvenile production estimate (or 0.5 percent of spring-run surrogates for yearlings)	None identified
Salvage or Loss Thresholds (annual): Hatchery winter-run Chinook salmon (loss)	None identified	90 percent of the greatest annual loss that occurred in the historical record from 2010 through 2018: 0.116 percent of the hatchery juvenile production estimate
Salvage or Loss Thresholds (annual): natural origin steelhead (salvage in original proposed action; loss in final proposed action)	3,000 (salvage)	90 percent of the greatest annual loss that occurred in the historical record from 2010 through 2018 for two separate periods: December-March (loss of 1,414 steelhead) and April-June 15 (loss of 1,552 steelhead)
Salvage or Loss Thresholds (annual): Green sturgeon (salvage)	100	None identified
Salvage or Loss Thresholds (annual): Old and Middle River action response when observed loss exceeds average historic loss	None identified	Reclamation and DWR will review information and seek technical assistance from NMFS

Element	February 5, 2019 (original) proposed action	September 19, 2019 (final) proposed action
Salvage or Loss Thresholds (annual): Old and Middle River action response when observed loss exceeds 50 percent of the loss threshold	-3,500 cfs Old and Middle River limit until the species-specific offramp[15] is met.	-3,500 cfs Old and Middle River limit until the species-specific offramp is met, unless Reclamation and DWR determine that further Old and Middle River restrictions are not required based on risk assessment. Reclamation and DWR will seek technical assistance from NMFS.
Salvage or Loss Thresholds (annual): Old and Middle River action response when observed loss exceeds 75 percent of the loss threshold	-2,500 cfs Old and Middle River limit until the species-specific offramp is met.	-2,500 cfs Old and Middle River limit until the species-specific offramp is met, unless Reclamation and DWR determine that further Old and Middle River restrictions are not required based on risk assessment. Reclamation and DWR will seek technical assistance from NMFS.
Storm Related Old and Middle River Flexibility		
Conditions when storm flex would not occur	Additional real-time Old and Middle River restrictions in effect	Additional real-time Old and Middle River restrictions in effect, plus some additional limits
End of Old and Middle River Management		

[15] In the proposed action and throughout this table, "species-specific offramp" refers to the conditions that would end OMR management for a particular species. Specifically, the June 14, 2019 proposed action defines the end of OMR management as follows: "OMR criteria may control operations until June 30 (for Delta Smelt and Chinook salmon), until June 15 (for steelhead/rainbow trout), or when the following species-specific off ramps have occurred, whichever is earlier:

- Delta Smelt: when the daily mean water temperature at Clifton Court Forebay reaches 25°C for 3 consecutive days;
- Salmonids:
  - when more than 95 percent of salmonids have migrated past Chipps Island, as determined by their monitoring working group, or
    - after daily average water temperatures at Mossdale exceed 72°F for 7 days during June (the 7 days do not have to be consecutive)."

So, for example, if, after conducting a risk assessment, Reclamation and DWR implemented a -3,500 cfs OMR limit action on June 3 after exceeding 50% of the April-June 15 steelhead loss threshold, that OMR action would not extend past June 15 due to the date-based offramp for OMR management for steelhead. Note that the -5,000 cfs OMR limit will be in effect until offramps for *all* species are met.

Element	February 5, 2019 (original) proposed action	September 19, 2019 (final) proposed action
Date-based offramp for Chinook salmon and steelhead	June 30 for Chinook salmon and steelhead	June 30 for Chinook salmon, June 15 for steelhead

In the proposed action and throughout this table, "species-specific offramp" refers to the conditions that would end OMR management for a particular species. Specifically, the June 14, 2019 proposed action defines the end of OMR management as follows: "OMR criteria may control operations until June 30 (for Delta Smelt and Chinook salmon), until June 15 (for steelhead/rainbow trout), or when the following species-specific off ramps have occurred, whichever is earlier:

- Delta Smelt: when the daily mean water temperature at Clifton Court Forebay reaches 25°C for 3 consecutive days;
- Salmonids:

o when more than 95 percent of salmonids have migrated past Chipps Island, as determined by their monitoring working group, or

o after daily average water temperatures at Mossdale exceed 72°F for 7 days during June (the 7 days do not have to be consecutive)."

So, for example, if, after conducting a risk assessment, Reclamation and DWR implemented a -3,500 cfs OMR limit action on June 3 after exceeding 50% of the April-June 15 steelhead loss threshold, that OMR action would not extend past June 15 due to the date-based offramp for OMR management for steelhead. Note that the -5,000 cfs OMR limit will be in effect until offramps for all species are met.

8.6.10 South Delta Export Facilities

Reclamation and DWR propose to have a minimum combined export rate of 1,500 cfs for human health and safety. This level of exports would meet the minimum level of water supplies obligated to senior water rights holders and minimum deliveries to wildlife refuges. This low level of exports is not expected to substantially impact Old and Middle River flows or alter hydrodynamics in the South Delta except under the very lowest of river inflow conditions. At an export level of 1,500 cfs however, the efficiency of the louvers that make up the primary fish screens at both the SWP and CVP decreases, and more fish that encounter the louvers are lost to the system through the louvers, or fail to enter the bypasses that lead to the secondary screens and the holding tanks. This risk is reduced by the reduction in the effects of the export pumping in the near-field and far-field areas of the south Delta adjacent to the location of the CVP and SWP. Reduced exports of 1,500 cfs are expected to produce more positive Old and Middle River flows and reduce the extent of the export's zone of influence in channels leading towards the pumps.

8.6.10.1 Tracy Fish Facility Improvements

8.6.10.1.1 Predator Removal (CO_2 injection)

A number of conservation measures are proposed to improve salvage efficiency at the Tracy Fish Collection Facility, including installing a carbon dioxide (CO_2) injection device to allow remote controlled anesthetization of predators in the secondary channels of the Tracy Fish Collection Facility by elevating the dissolved CO_2 concentration in the secondary channels. These proposed action components could potentially benefit juvenile winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon through greater salvage efficiency and reduced mortality related to predation.

Reclamation proposes to construct a CO_2 injection device within the secondary channel of the Tracy Fish Collection Facility. The device will diffuse CO_2 gas into the water column of water moving into the secondary channel when removal of predators is warranted. The device has not been explicitly described in the biological assessment, but is likely to consist of a manifold with diffuser pipes through which CO_2 gas is diffused into the water column of the secondary channel. Construction of such a device will require that the secondary channels be dewatered for periods of time to install the infrastructure. Construction of the device will occur during the August through October in-water construction period. Operations of the device will, at a minimum, occur during the period in which listed salmonids and sDPS green sturgeon are present, and may occur year-round.

8.6.10.1.2 Exposure of Listed Salmonids to Construction

During construction of the CO2 injection system, winter-run Chinook salmon, CV spring-run Chinook salmon, and CCV steelhead are not expected to be exposed to the effects of construction, based on the timing of in-water construction (August–October) and the typical seasonal occurrence and salvage timing in the Delta of listed salmonids. Although the construction window avoids the majority of the juvenile salmonid migration period in the Delta, a few migrating juvenile salmonids could still occur during the in-water work window. To minimize or avoid adverse effects to these few fish due to construction activities, Reclamation proposes to minimize risk by incorporating the appropriate avoidance and minimization measures (U.S. Bureau of Reclamation 2019c) into the construction protocol.

8.6.10.1.3 Exposure of sDPS Green Sturgeon to Construction

Juvenile sDPS green sturgeon can occur in the Delta year-round and, therefore, have the potential to be exposed to the effects of construction of the CO_2 injection device proposed for the Tracy Fish Collection Facility improvements. If construction impacts the efficiency of green sturgeon salvage, there could be a minor effect to a small number of individual fish, although risk would be minimized through the incorporation of appropriate avoidance and minimization measures. As with other proposed construction in the Delta under the proposed action, the timing of early out-migrating adult sDPS green sturgeon occurrence in the Delta could overlap with CO_2 injection device construction as part of Tracy Fish Collection Facility improvements. Application of avoidance and minimization measures and the small scale of the in-water construction would minimize the potential for any effects to individual adult sDPS green sturgeon.

8.6.10.1.4 Risk to Listed Salmonids during Construction

The risk to listed salmonids should be minimal as the construction of the CO_2 injector occurs during the in-water work window of August through October when listed salmonids are least likely to be present. Incorporation of the avoidance and minimization measures will further reduce the potential of any risk to listed salmonids. Furthermore, installation of the injector will occur in the dewatered secondary channel. The secondary is typically dewatered to work on the secondary travelling screens or to remove predators, and flushes all fish in the secondary channel into the holding tanks where they are held until release. During any dewatering of the secondary channel, salvage operations are suspended, and any listed salmonid present may pass through the primary louvers into the intake channel leading to the export pumps where it is lost to the system.

8.6.10.1.5 Risk to sDPS Green Sturgeon during Construction

The risk to sDPS green sturgeon is considered to be low. Although green sturgeon are present year-round in the Delta, the incorporation of the avoidance and minimization measures will further reduce the risk of exposure to construction effects. As described for the listed salmonids, the secondary channel will be dewatered, and any sDPS green sturgeon present will be flushed into one of the holding tanks for future release. There is the potential that during the period that the secondary channel is dewatered and salvage operations are halted, that any individual sDPS green sturgeon present in the primary channel may pass through the primary louvers into the intake channel and be lost to the system. This is considered unlikely as the probability of any sDPS green sturgeon being present in the primary at the time of dewatering is low, given their rarity in salvage at any time.

8.6.10.1.6 Exposure of Listed Salmonids and sDPS Green Sturgeon during Operations

The CO_2 injection system is intended to be used to remove predators during the periods of the year when listed salmonids are present in salvage. Therefore, winter-run Chinook salmon, CV spring-run Chinook salmon, and CCV steelhead have the potential to be present during the use of the injector system during predator removals. Any listed salmonid present in the secondary channel at the time of the predator removal will be exposed to the effects of the elevated dissolved CO_2 concentrations in the water of the secondary channels.

8.6.10.1.7 Risk to Listed Salmonids and sDPS Green Sturgeon during Operations

Once installed, Reclamation proposes to use the CO_2 injection device to clear predators from the secondary channel on a regular basis. 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 CO_2 is injected into the secondary channel. Predators that are anesthetized by the CO_2 are drawn into the holding tanks by the water flow where they can be removed from the system during regular salvage counts and potentially relocated to waters outside of the Delta (e.g., Delta Mendota Canal, Bethany Reservoir). Listed salmonids may be exposed to the effects of the increased dissolved CO_2 (hypercapnia) during predator removals and also become anesthetized. A proportion of these fish, due to their smaller size, may die due to the effects of the increased CO_2 levels in their blood stream. 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 the exposure to the elevated CO_2 concentrations in the secondary channels during a predator clean out.

8.6.10.1.8 Tracy Fish Collection Facility Release Sites Improvements

In addition to incorporating the CO_2 injection system into the secondary channels to reduce predator density, Reclamation is also proposing to modify its procedure for releasing salvaged fish back into the Delta. Currently, Reclamation manages two release sites in the Delta, one on the Sacramento River near Horseshoe Bend, and the other on the San Joaquin River immediately upstream of the Antioch Bridge. An additional two sites managed by DWR are also shared with Reclamation. Reclamation is proposing to add additional release sites in the western Delta outside the influence of the export operations. Additional release sites, coupled with a rotating release schedule between sites, is believed to reduce the potential for predators to habituate to a given release site as a source of food. In theory, if the number of release sites is low, and the release of salvaged fish occurs frequently (up to several times a week per site) then predators will associate the release locations and the release site pipe as a source of food in the form of released fish from the salvage operations exiting from the end of the pipe, including listed salmonids. Although some loss will occur due to predation at the additional sites, the current belief is that the cumulative loss due to predation from all release sites should be reduced due to lower predator density at each release site. However, the lack of information regarding the locations of the alternative release sites, and the intended construction actions and their impacts do not permit a complete effects analysis to be done for this proposed action component, thus it will be considered as a programmatic consultation.

8.6.10.1.9 Tracy Fish Collection Facility Infrastructure Improvements

Reclamation proposes to improve the infrastructure of the Tracy Fish Collection Facility to reduce the loss of entrained fish by: (1) incorporating additional fish exclusion barrier technology into the primary fish removal barriers, (2) incorporating additional debris removal systems at each trash removal barrier, screen, and fish barrier, (3) Constructing additional channels to distribute the fish collection and debris removal among redundant paths through the facility, (4) Construct additional fish handling systems and holding tanks to improve system reliability; and (5) Incorporate remote operation into the design and construction of the facility. These physical infrastructure improvements are likely to enhance the overall efficiency of the salvage facility while ultimately reducing the level of loss of entrained fish. In particular, the construction of additional channels to distribute the fish collection and debris removal among several redundant pathways has the potential to reduce or eliminate the issue of open louver bays during the cleaning process, as is the case at the Skinner Delta Fish Protective Facility with its multiple primary inlet channels that can be operated independently from each other.

However, the lack of details and specificity of design and construction schedule do not allow for the analysis of project effects for this proposed action component. The scope of this proposed action component will likely require several years to complete infrastructure improvements and testing, and may require numerous construction actions, all of which have not been described. Therefore, this proposed action component will be considered as a programmatic consultation.

8.6.10.2 Skinner Delta Fish Protective Facility Improvements

The proposed action components associated with Skinner Delta Fish Protective Facility improvements involve predator control efforts and are intended to reduce predation on listed fish species following their entrainment into Clifton Court Forebay. This improvement could benefit juvenile winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon entrained into Clifton Court Forebay by reducing predation and pre-screen loss (mortality).

DWR proposes to continue the implementation of projects to reduce mortality of listed salmonids and sDPS green sturgeon at the SWP facilities. These projects include studies to reduce the predation of listed fish in the Clifton Court Forebay and operational changes that have the potential to benefit listed fish and reduce mortality. Specifically, DWR propose to continue studies regarding: (1) the electro-fishing of predatory fish and their relocation from Clifton Court Forebay (the Predator Reduction Electrofishing Study (PRES)); (2) controlling aquatic weeds that provide habitat for predatory fish; (3) a predatory fish relocation study (PFRS) that uses commercial fishing techniques to capture predators and relocating them away from Clifton Court Forebay; and (4) developing operational changes (i.e., preferential pumping through the Federal Jones Pumping Plant) that provide additional protection to listed fish when they are present.

8.6.10.2.1 Deconstruct the Action - Predator Reduction Electrofishing Study (PRES)

DWR has already completed a 3-year study of the PRES, but is proposing to continue the study for an additional 2 years (California Department of Water Resources 2018a). The PRES study will take place within Clifton Court Forebay and will collect and relocate predatory fish in order to study the effects of the predator removal on survival of listed salmonids. The PRES will use three electrofishing boats that will be fished concurrently within Clifton Court Forebay to capture target predatory fish species (striped bass (*Morone saxatilis*), largemouth bass (*Micropterus salmoides*), spotted bass (*M. punctulatus*), channel catfish (*Ictalurus punctatus*), white catfish (*Ameiurus catus*), black bullhead (*A. melas*), and brown bullhead (*A. nebulosus*)). These species (or other predatory species collected but not listed) will be re-located to Bethany Reservoir. The three electrofishing boats will make systematic sweeps through Clifton Court

Forebay. The proposed fish collections will occur 4 days a week from January to June, as conditions allow. No collection will occur once temperatures in the Clifton Court Forebay exceed ~21°C. This schedule may be altered for safety reasons (weather or boating conditions), staffing, Clifton Court Forebay hunting events or environmental conditions (presence of aquatic vegetation), or other unforeseen variables. If listed fish are incidentally collected during the electrofishing, crews will recover them, identify them, take and archive genetic tissue samples as permitted, and release the species back into Clifton Court Forebay.

8.6.10.2.2 Exposure of Listed Fish to the PRES

Listed fish are expected to be present within the Clifton Court Forebay during the implementation of the PRES. From January to June, winter-run and CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon are expected to be present and potentially exposed to the effects of the electrofishing operations within the confines of Clifton Court Forebay.

8.6.10.2.3 Response of Listed Salmonids to the PRES

Listed salmonids that are present in the vicinity of the electrofishing boats will be exposed to the electrical current within the water column when the boats are actively fishing. Since the boats are targeting larger fish species that would be capable of predating on juvenile Chinook salmon or CCV steelhead, less voltage is required to stun these fish. The greater length of the predatory fish creates a greater voltage gradient along the length of the fish, and thus less voltage is needed to anesthetize the fish in the electric field. However, larger fish such as sDPS green sturgeon, adult salmonids, or even larger CCV steelhead smolts may be susceptible to the electric field and become stunned. As evidence of this risk, the cumulative incidental take of Chinook salmon and steelhead from the previous 3 years of study is 152 Chinook salmon and 50 steelhead observed moving into the vicinity of the electrofishing boats in response to the electric field. The protocol for the electrofishing crews is to stop fishing if they observe salmonids entering the electric field of the boats, and move to another location. All of the salmonids observed during the first 3 years of study immediately recovered when the electrofishing equipment was turned off.

8.6.10.2.4 Response of sDPS Green Sturgeon to the PRES

As discussed above, larger fish are more susceptible to the effects of electrofishing due to their greater length and the larger voltage gradient across their body. During the previous 3 years of the PRES, no sDPS green sturgeon were reported in the incidental catch of listed fish. This could be due to several factors. sDPS green sturgeon are benthic oriented and prefer deeper waters to hold in. It is possible that the electric field used in the PRES did not reach deep enough into the water column to affect sDPS green sturgeon, or that the habitats that were sampled did not contain any sDPS green sturgeon to begin with. However, if larger sDPS green sturgeon were exposed to the electric field, there is the potential for notochord injury due to the reflexive muscle contractions caused by the electric field. The larger the fish, or the greater the voltage gradient, the more violent and forceful the contractions can be, and the higher the probability of injury (Holliman and Reynolds 2002; McMichael et al. 1998).

8.6.10.2.5 Risk to Listed Salmonids

There is an inherent risk to listed salmonids associated with the proposed use of electrofishing in the PRES. However, due to the targeting of larger predatory fish, most of the listed salmonids in the Clifton Court Forebay will be much smaller than the size of the predators, and, therefore, the effects of the electric field generated by the electrofishing equipment should not physically harm them. As stated above, the protocols used by the electrofishing teams require them to turn off the equipment if they observe any salmonids being drawn to the electric field. This prevents the fish from becoming incapacitated, and vulnerable to predation, either by avian predators or by predatory fish.

8.6.10.2.6 Risk to Southern Distinct Population Segment Green Sturgeon

Like listed salmonids, there is an inherent risk associated with the use of electrofishing in the PRES. Due to the larger size of sDPS green sturgeon, the risk of injury is greater than to the smaller salmonids. Water depth and protocols that require the turning off of the equipment if listed fish are observed will reduce the risk to sDPS green sturgeon.

8.6.10.2.7 Deconstruct the Action - Predator Fish Relocation Study (PFRS)

The PFRS proposes to use commercial fishing techniques to capture predatory fish within the Clifton Court Forebay. These techniques will include both passive and active fishing methods. The methods include beach seines, purse seines, fyke traps, hoop nets, and trawls. The size of the net mesh will be no smaller than 2 inches stretched. Each fish collection method is expected to sample different habitats in Clifton Court Forebay and target different predatory species. The specific habitats sampled by collection methods include the Scour Hole, deep habitat (> 60 ft. deep) immediately downstream of the Radial Gates, the Intake Channel leading to the Skinner Delta Fish Protective Facility, shoreline habitat, and shallow mudflat areas (< 6 ft. deep) throughout Clifton Court Forebay. The details of each method and the frequency of sampling are described in a separate biological assessment developed for this study (California Department of Water Resources 2018a). The PFRS was proposed as an additional study to be implemented by DWR to reduce predation in Clifton Court Forebay during the ROC on LTO consultation, replacing the fishing incentive program originally proposed. Proposed fish collection will take place Monday through Thursday each week from October through June, as conditions allow. No collection will occur once temperatures in the Clifton Court Forebay exceed ~21°C. This may follow the same general schedule as PRES, but could be altered for safety reasons (weather or boating conditions), staffing, Clifton Court Forebay hunting events or environmental conditions (presence of aquatic vegetation), or other unforeseen variables. Any predator fish collected will be transported to Bethany Reservoir and released. There is no access from Bethany Reservoir back into the Delta.

During fish collection, listed species including CV spring-run Chinook salmon, winter-run Chinook salmon, sDPS green sturgeon, and CCV steelhead could be captured. Each crew will identify and enumerate all ESA-listed fish species captured as incidental bycatch, take tissue samples and archive with CDFW, as appropriate, and release the species back into Clifton Court Forebay.

8.6.10.2.8 Exposure of Listed Fish to the PFRS

Listed fish are expected to be present within the Clifton Court Forebay during the implementation of the PFRS. From January to June, winter-run Chinook salmon and CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon are expected to be present and potentially exposed to the effects of the fishing operations within the confines of Clifton Court Forebay. From October through December, only sDPS green sturgeon are expected to be present.

8.6.10.2.9 Response of Listed Salmonids to the PFRS

Although most juvenile Chinook salmon should be small enough to escape through the mesh of the nets, some of the larger fish may become entangled when they try to swim through the net. When fish entangle themselves in the net, they risk damaging their sensitive gill structures or injuring their eyes. Furthermore, abrasions along the body may become infected. These injuries will reduce the fitness of the fish and may lead to death or predation in its weakened state. In addition, listed salmonids that are entrapped in the fyke, traps or hoop nets with predators may be predated upon if they cannot escape through the mesh. During each set of the nets, study personnel are on hand to monitor the nets. For beach seines, purse seines, and trawls, the duration of the net set is short and most listed fish should be recovered alive and released back into the waters of Clifton Court Forebay. The fyke traps and hoop nets are fished overnight and the risk to fish increases due to the longer soak time. For all fishing techniques, there are protective fish handling and recovery protocols that are designed to minimize the stress of capture of any listed salmonid. Listed fish are removed from the nets or traps first and processed. Fish will be allowed to recover in holding units and will only be released when they regain fully normal behavior and function.

8.6.10.2.10 Response of Southern Distinct Population Segment Green Sturgeon

Entanglement of sDPS green sturgeon in the mesh of the nets is likely due to their behavior of rolling in the nets when captured. As described above for listed salmonids, fish are immediately removed from the nets when the haul is completed and processed. The fish handling and recovery protocols are designed to minimize the stress of capture and fish are allowed to recover fully before being released back into the waters of Clifton Court Forebay.

8.6.10.2.11 Risk to Listed Salmonids

The PFRS will be conducted during the period when juvenile listed salmonids are present in Clifton Court Forebay and they will be vulnerable to capture by the different commercial fishing techniques employed. Capture in the beach seine, purse seine, or trawl should have a relatively low risk of mortality due to the short time of each fishing event and the proposed fish handling and recovery protocols. In contrast, the fyke trap and hoop nets pose a greater risk due to the longer soak times overnight. Captured salmonids will be exposed to predation in the traps if they cannot escape through the mesh, or may die or be eaten if they become ensnared in the mesh trying to escape.

8.6.10.2.12 Risk to Southern Distinct Population Segment Green Sturgeon

Some sDPS green sturgeon are likely to be present in Clifton Court Forebay during the study and will be vulnerable to the fishing techniques employed. Like the listed salmonids, risk to sDPS green sturgeon is low for the beach seines, purse seines, and trawls due to the short time of the fishing events and the lower probability that they will be present in the areas available for beach seining or within the portion of the water column vulnerable to the purse seines or surface trawls. Benthic trawls that target deeper water are more likely to capture sDPS green sturgeon, but the short duration of the trawl will allow any captured sDPS green sturgeon to be quickly processed and released. Capture of sDPS green sturgeon in the fyke trap or hoop nets will result in longer periods of time in which the fish may be entangled in the nets before processing. However, based on other studies in the Delta, the overnight soak time should not create sufficient stress to result in death of the captured fish.

8.6.10.2.13 Deconstruct the Action - Aquatic Weed Control for Predator Habitat

DWR proposes to control aquatic weeds that provide habitat for predatory fish. Most of this weed control will be focused on specific areas and may only require spot removal or use of a mechanical harvester to remove the floating or shallow submerged aquatic vegetation. These actions will typically take place in the summer and will coincide with the larger aquatic weed control program in Clifton Court Forebay.

8.6.10.2.14 Exposure of Listed Fish to Aquatic Weed Control for Predator Habitat

Listed salmonids are not expected to be present within the Clifton Court Forebay during the implementation of the weed control program to reduce habitat for predatory fish during the summer, however sDPS green sturgeon may be present at this time. From January to June, winter-run and CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon are expected to be present and potentially exposed to the effects of the reduced vegetation cover for predators.

8.6.10.2.15 Response of Listed Salmonids to Aquatic Weed Control for Predator Habitat

Listed salmonids should benefit from the removal of submerged and floating vegetation that serves as habitat for ambush predators. With less habitat to hide in, ambush predators will have to move away from the cleared areas, thus reducing the potential exposure of listed salmonids to ambush attacks in a greater area of Clifton Court Forebay.

8.6.10.2.16 Response of sDPS Green Sturgeon to Aquatic Weed Control for Predator Habitat

There is likely little response to the cleared habitat from sDPS green sturgeon. sDPS green sturgeon are probably not as vulnerable to ambush predators as salmonids since they inhabit deeper portions of Clifton Court Forebay and are likely to congregate in areas devoid of any vegetation (i.e., deep scour hole).

8.6.10.2.17 Risk to ESA-Listed Salmonids to Aquatic Weed Control for Predator Habitat

Since the action is likely to occur during the summer, no listed salmonids are expected to be present. Therefore the risk is considered to be minimal.

8.6.10.2.18 Risk to Southern Distinct Population Segment Green Sturgeon

The risk to sDPS green sturgeon is minimal due to the area in which the sDPS green sturgeon are likely to be found. The areas in which aquatic weed control of floating and shallow submerged weeds is not the type of habitat that sDPS green sturgeon are likely to be found in.

8.6.10.2.19 Deconstruct the Action - Operational Changes when ESA-Listed Fish are Present

DWR proposes to shift exports from the SWP to the CVP under the new addendum to the *Coordinated Operations Agreement* provisions signed on December 12, 2018, when it would benefit listed fish species. An "Operational Changes Summary" document (DWR, March 1, 2019) from DWR indicates that in order to reduce pre-screen loss in Clifton Court Forebay, the SWP will shift some of its "pumping at Banks Pumping Plant to the Central Valley Project at Jones Pumping Plant when listed species are present. The amount of shifted pumping under Stage 1 Joint Point of Diversion will be limited by the operational or available physical capacity at Jones Pumping Plant. Any SWP pumping greater than what can be shifted to the CVP would still be exported through Clifton Court Forebay and Banks Pumping Plant. A minimum SWP pumping amount of approximately 300 cfs is required to support Byron-Bethany and South Bay Aqueduct water needs. This action could occur anytime between January 1 and June 15."

8.6.10.2.20 Exposure of ESA-Listed Fish to the Operational Changes when ESA-Listed Fish are Present

Listed salmonids are typically present in salvage from December through June of each year at the south Delta export facilities. The salvage of juvenile winter-run Chinook salmon typically occurs from December through March. Salvage of CV spring-run Chinook salmon may occur as early as December and January (yearling life history phase) and extends through May and early June for young-of-the–year juveniles. CCV steelhead may be salvaged in any month of the year, but primarily from December through June. The salvage of sDPS green sturgeon may occur during any month of the year based on their year-round presence in the Delta. Listed salmonids and sDPS green sturgeon will be present during the periods when this shift in exports is likely to occur. The shifting of exports is predicated on the presence of listed fish in salvage at the SWP, and the availability of capacity at the CVP.

8.6.10.2.21 Response of Listed Salmonids to the Operational Changes when ESA-Listed Fish are Present

This proposed action component is designed to reduce the number of listed salmonids lost through the Skinner Delta Fish Protective Facility. However, shifting exports to the CVP may result in more fish being entrained into the Tracy Fish Collection Facility, but the combined loss between the two facilities should be reduced, as the loss expansion for salvaged fish is less at the CVP than it is at the SWP. This difference is due to the much higher pre-screen loss associated with Clifton Court Forebay that influences the magnitude of loss at the SWP.

8.6.10.2.22 Response of sDPS Green Sturgeon to the Operational Changes when ESA-Listed Fish are Present

sDPS green sturgeon should have a similar positive response to the shifting of exports to the CVP. Although the rate of loss for sDPS green sturgeon is unknown, lower entrainment into Clifton Court Forebay would benefit sDPS green sturgeon by keeping them out of Clifton Court Forebay where they can become trapped behind the radial gates.

8.6.10.2.23 Risk to ESA-Listed Salmonids to the Operational Changes when ESA-Listed Fish are Present

The risk of predation to listed salmonids is likely to be reduced by reducing entrainment into Clifton Court Forebay and shifting exports to the CVP. By reducing the likelihood of entrainment into Clifton Court Forebay, the exposure of listed salmonids to the predator field in Clifton Court Forebay is reduced and overall combined survival between the two facilities is expected to increase.

8.6.10.2.24 Risk to sDPS Green Sturgeon to the Operational Changes when ESA-Listed Fish are Present

The risk of entrainment into Clifton Court Forebay should be reduced for sDPS green sturgeon. Remaining outside of Clifton Court Forebay should be a benefit to individual fish and the overall population as fish will be free to migrate without having their movements delayed by being trapped behind the radial gates leading into Clifton Court Forebay.

8.6.10.2.25 Clifton Court Forebay Aquatic Weed and Algal Bloom Management

8.6.10.2.26 Deconstruct the Action – Clifton Court Forebay Aquatic Weed and Algal Bloom Management

DWR has proposed to apply herbicides and use mechanical harvesters on an as-needed basis to control aquatic weeds and algal blooms in Clifton Court Forebay. Herbicides may include Aquathol® K, chelated copper herbicides (copper-ethylenediamine complex and copper sulfate pentahydrate) and copper carbonate compounds, or other copper-based herbicides; and algaecides may include peroxygen-based algaecides (e.g. PAK 27) 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 *Egeria densa*, curly-leaf pondweed, sago pondweed, and southern naiad; however, other native and invasive aquatic weeds are present as well. Excessive weeds fragment and clog the trashracks 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 trashracks and louver array, that the pumps at the Banks Pumping Facility 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 water. In addition, dense stands of aquatic weeds provide cover for unwanted predators that prey on listed species within the Clifton Court Forebay.

Aquatic weed control is included as a conservation measure to reduce mortality of ESA-listed fish species within the Clifton Court Forebay.

DWR has applied herbicides in Clifton Court Forebay since 1995, typically during the spring or early summer when listed salmonids have been present in Clifton Court Forebay. From 1995 to 2006, complex copper herbicide was applied once or twice annually usually during May or June to target early plant growth when the herbicide has greatest efficacy; though applications have occurred as early as May 3rd and as late as September 10th. Copper-based herbicides are very effective at controlling *Egeria*, the predominant aquatic weed in Clifton Court Forebay at that time. DWR temporarily stopped applying herbicides in Clifton Court Forebay after the 2006 season when sDPS green sturgeon was listed as a threatened species. New operational procedures for aquatic herbicide applications in Clifton Court Forebay were identified in the Modified 2011 Project Description for the CVP and SWP as part of Reclamation's Biological Assessment. The procedures, which limited herbicide applications to July 1 through August 31 (or as authorized by NMFS or FWS), were developed to allow resumption of aquatic herbicide applications in Clifton Court Forebay while avoiding potential toxicity from exposure to copper to salmon, steelhead, and sturgeon. Copper-based herbicides present toxicity issues to salmonids and sDPS green sturgeon due to their high sensitivity to copper at both sublethal and lethal concentrations. In response to an increasing abundance of aquatic weeds that culminated in the failure of several fish louvers of the Skinner Delta Fish Protective Facility in September 2014, treatments resumed in 2015.

As documented in the 2014 California Department of Food and Agriculture (CDFA) aquatic plant survey, the aquatic weed community in Clifton Court Forebay shifted from *Egeria densa*-dominant to pondweed dominant. In August 2015, DWR received approval from NMFS to use endothall, a fast-acting contact herbicide that is effective at controlling aquatic weeds in Clifton Court Forebay. 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 2016). Additionally, DWR's 2016 Aquatic Pesticides Application Plan states that since 2006 a mechanical harvester has been used to remove weeds near the outlet from Clifton Court Forebay into the approach canal leading to the trash racks in front of the Skinner Delta Fish Protective Facility. The harvester is used for regular removal of pondweeds to help maintain flows to the Skinner Delta Fish Protective Facility and Banks Pumping Plant (California Department of Water Resources 2016).

Aquatic weed and algae treatments is proposed to occur on an as-needed basis depending upon the level of vegetation biomass, the cyanotoxin concentration from the harmful algal blooms (HAB), or concentration of taste and odor compounds. The frequency of aquatic herbicide applications to control aquatic weeds is not expected to occur more than twice per year, as demonstrated by the history of past applications. 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. The frequency of algaecide applications to control HABs is not expected to occur more than once every few years, as indicated by monitoring data and demonstrated by the history of past applications. Treatment areas are typically about 900 acres, and no more than 50 percent of the 2,180 total surface acres.

DWR proposes to conduct the following operational procedures:

- Apply Aquathol® K and copper-based aquatic pesticides, and use mechanical harvesters, as needed, from June 28 to August 31.
- Apply Aquathol® K and copper-based aquatic pesticides, as needed, prior to June 28 or after August 31 if the average daily water temperature within Clifton Court Forebay is at or above 25°C and if Delta Smelt, salmonids and sDPS green sturgeon are not at additional risk from the treatment as conferred by NMFS and FWS.
    - Prior to treatment outside of the June 28 to August 31 timeframe, DWR will notify and confer with NMFS and FWS on whether ESA-listed fish species are present and at risk from the proposed treatment.
- Apply Aquathol® K and copper-based aquatic pesticides, as needed, during periods of activated Delta Smelt and salmonid protective measures and when average daily water temperature in Clifton Court Forebay is below 25°C if the following conditions are met:
    - Prior to treatment outside of the June 28 to August 31 timeframe, DWR will notify and confer with NMFS and FWS on whether ESA-listed fish species are present and at risk from the proposed treatment.
    - The herbicide application does not begin until after the radial gates have been closed for 24 hours or after the period of predicted Delta Smelt and salmonid survival within Clifton Court Forebay (e.g. after predicted mortality has occurred due to predation or other factors) has been exceeded, and
    - The radial gates remain closed for 24 hours after the completion of the application, unless it is conferred that rapid dilution of the herbicide would be beneficial to reduce the exposure duration to listed fishes present within the Clifton Court Forebay.
- Apply peroxygen-based aquatic algaecides, as needed, year-round.
    - There are no anticipated impacts on fish with the use of peroxygen-based aquatic algaecides in Clifton Court Forebay during or following 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 Clifton Court Forebay.
- For Aquathol® K and copper compounds, the radial intake gates will be closed at the entrance to Clifton Court Forebay 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 and up to 24 hours after treatment to allow for the recommended duration of contact time between the aquatic pesticide and the treated vegetation or cyanobacteria in Clifton Court Forebay, 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.

- Application will be made by a licensed applicator under the supervision of a California Certified Pest Control Advisor.
- Aquatic herbicides and algaecides will be applied by boat or by aircraft.
    - 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 or aircraft. No aerial spray applications will occur during wind speeds above 15 mph to prevent spray drift. Application would be to the smallest area possible that provides relief to SWP operations or water quality. No more than 50 percent of Clifton Court Forebay will be treated at one time.
- Water quality samples to monitor copper and endothall concentrations within or adjacent to the treatment area, per NPDES permit requirements, will be collected before, during and after application. Additional water quality samples may be collected during and following treatment for drinking water compliance purposes. 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. Dissolved oxygen concentration will be measured prior to and immediately following application within and adjacent to the treatment zone.
- A spill prevention plan will be implemented in the event of an accidental spill.

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 Clifton Court Forebay. Additionally, prior to aquatic herbicide applications following gate closures, the water will be drawn down in the Clifton Court Forebay via the Banks Pumping Plant. This drawdown helps facilitate the movement of fish in the Clifton Court Forebay toward the fish diversion screens and into the fish protection facility, and lowers the water level in the Clifton Court Forebay to decrease the total amount of herbicide need to be applied, per volume of water, and aides in the dilution of any residual pesticide post-treatment. Following reopening of the gates and refilling of Clifton Court Forebay, the rapid dilution of any residual pesticide and the downstream dispersal of the treated water into the California Aquaduct via Banks Pumping Plant reduces the exposure time of any fish species present in Clifton Court Forebay.

8.6.10.2.27 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 Clifton Court Forebay will occur normally during the summer months beginning June 28 through August 31. Some exceptions outside of this time frame are proposed on an "as needed basis" after DWR confers with NMFS and FWS and it is determined that listed fish are not present in Clifton Court Forebay. The probability of exposing salmonids to the endothall- or copper-based herbicides or harvesters during the normal summer application period is very low due to the life history of Chinook salmon and CCV steelhead in the Delta region. Migrations of juvenile winter-run Chinook salmon and CV spring-run Chinook salmon primarily occur outside of the summer period in the Delta. CCV 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 winter-run Chinook salmon and spring-run Chinook salmon primarily occur outside of the summer period in the Delta. CCV 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 sub-adult sDPS green sturgeon are recovered year-round at the CVP/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 at present. Therefore, juvenile and sub-adult sDPS green sturgeon are likely to be present during the application of the herbicides or mechanical harvesting.

8.6.10.2.28 Assess Species Response to the Application of Herbicides and Algaecides

8.6.10.2.29 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 part per million (ppm) or 1,000 parts per billion (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 Clifton Court Forebay. 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 12 hours but before 24 hours to resume operations. Opening the radial gates prior to 24 hours would enable the rapid dilution of residual copper and thereby shorten the exposure duration of ESA-listed fish to the treatment. No more than 50 percent of the surface area of Clifton Court Forebay 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 (96hr-LC50) and 7 days (7d LC50) as well as determining the maximum acceptable toxicant concentration level (MATC) to exposed organisms. CDFG found that the 96hr-LC50 for fathead minnows (*Pimephales promelas*) was 0.31 ppm (0.18 – 0.53 ppm 95 percent confidence limit) and the 7d- LC50 was 0.19 ppm. The MATC was calculated as 0.11 ppm Komeen® in the water column. Splittail (*Pogonichthys macrolepidotus*), a native cyprinid minnow, was also tested by CDFG. The 96hr-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 (96hr-EC50) and 96hr-LC50. Wagner et al. (2017) found that for brook trout (*Salvelinus fontinalis*), the 96hr-EC50 was 26.2 ppm and the 96hr-LC50 was 28.2 ppm. The same study found that for fathead minnows, the 96hr-EC50 and 96hr-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. 2005a; Dwyer et al. 2000; 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 (*Oncorhynchus spp*.) 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 (BLM) (U.S. Environmental Protection Agency 2003) with a Genus Mean Acute Value (GMAV) of 29.11 ppb of copper. In comparison, fathead minnows, the standard EPA test fish for aquatic toxicity tests, have a GMAV of 72.07 ppb of copper. Therefore, salmonids are approximately 3 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 nominal water hardness of 100 mg/l (as $CaCO_3$). 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 (EEG) responses to the stimulant odor, L-serine (10-3 M), 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 EEG response recovery to the stimulus odor were 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 one-hour exposure, and were nearly identical after four hours of exposure. A more recent olfactory experiment (Baldwin et al. 2003) examined the effects of low dose copper exposure on coho salmon (*O. kisutch*) 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 white 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 were related to their social rank in the hierarchy of the tank. The increased stress levels of subordinate fish, as indicated by stress hormone levels, is 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 sub-adult green sturgeon in the wild.

Current EPA National Recommended Water Quality Criteria and the California Toxics Rule standards promulgate a chronic maximum concentration (CMC) of 5.9 µg/l and a continuous concentration criteria of 4.3 µg/l for copper in its ionized form. The dissociation rates for the chelated copper molecules in the copper-based herbicide formulations were unknown at the time of this consultation, so that NMFS staff could not calculate the free ionic concentration of the copper constituent following exposure to water. However, the data from the toxicity studies mentioned above indicates 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.

8.6.10.2.30 Aquathol® K

Aquathol® K is registered for use in California and has effectively controlled pondweeds and southern naiad in Clifton Court Forebay 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 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 (Endothall 1995). 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 Forest Service 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 (WI DNR) 2012).

The Aquathol® K label recommends application concentrations between 0.75 and 5.0 ppm depending on target plant species, with a maximum of 30 ppm over the course of a treatment season. The EPA maximum concentration allowed for Aquathol® K is 5 ppm. The label requires a 7-day wait period between 5 ppm applications. There are no wind, temperature, or irrigation restrictions on the Aquathol® K label. The concentrated product should not be permitted to contact crops. The endothall concentration in potable water must be less than 0.1 ppm, and application requires a minimum setback of 600 feet from an active potable water intake unless the intake is shut off during treatment. The label states that Aquathol® K should not be used in brackish or saltwater. The NPDES receiving waters limit is 100 ppb.

USEPA 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 >150 ppm and >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 9-12 ppm. A study on the ecotoxicity of endothall commissioned by CDBW 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 > 500 ppm) for rainbow trout. Figure 122 provides an illustration of endothall estimated Effects Concentration (EC), Lethal Concentration for 50 percent of the organisms (LC50), No Observable Effect Concentration (NOEC), and Lowest Observable Effect Concentration (LOEC) 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 impaired weight for the fathead minnow at 3.1 ppm and NOEC for Chinook salmon at approximately 3.5 ppm.

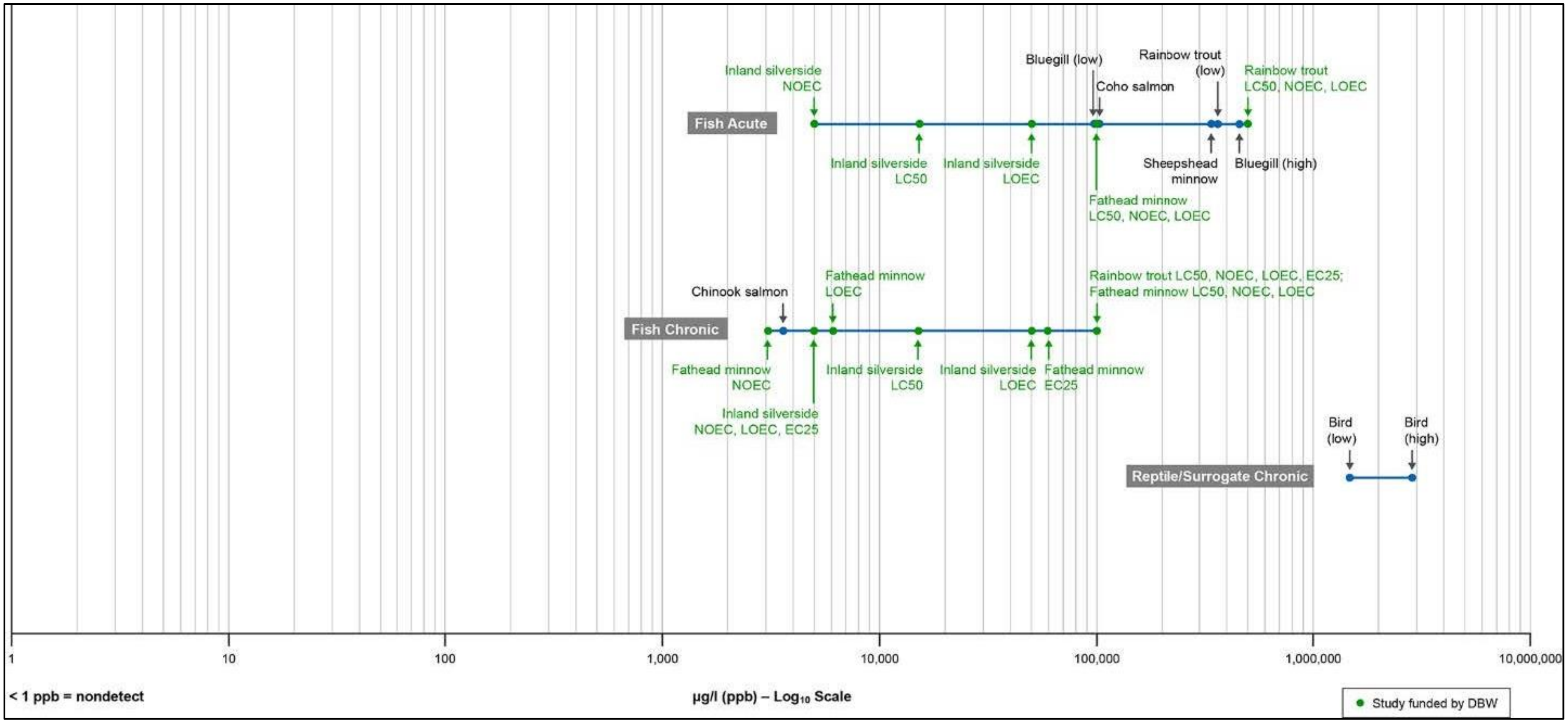


Figure 122. Exposure concentrations for surrogate and fish species endpoint effects for endothall (µg/L or ppb).

Source: California Department 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 Clifton Court Forebay, 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 Clifton Court Forebay depth— Aquathol® labeling (Aquathol SDS) recommends 0.75 ppm to 3.0 ppm for Pondweeds (*Potamogeton* spp.) (United Phosphorus 2016). 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 24 hours 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. No more than 50 percent of the surface area of Clifton Court Forebay will be treated at one time. Due to the lack of data on 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.

8.6.10.2.31 Peroxygen-Based Algaecides

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 (OMRI). PAK 27, or 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 (United Phosphorus 2016). These data reflect low toxicity effects on fish. Due to the lack of data on effects of peroxygen-based algaecides to surrogates for ESA-listed salmonids or 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 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 Clifton Court Forebay. 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 HABs is not expected to occur more than once every few years, and no more than 50 percent of the surface area of Clifton Court Forebay will be treated at one time, it is unlikely that algal decomposition will lead to sufficient oxygen depletion to result in fish mortality.

8.6.10.2.32 Assess Species Response to the Mechanical Harvesting

DWR proposes to continue using mechanical methods to manually remove aquatic weeds. A debris boom and an automated weed rake system continuously remove weeds entrained on the trashracks. During high weed load periods such as late summer and fall when the plants senesce and fragment or during periods of hyacinth entrainment, boat-mounted harvesters are operated on an as-needed basis to remove aquatic weeds in Clifton Court Forebay and the intake channel upstream of the trashracks and louvers. The objective is to decrease the weed load on the trashracks 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 rate for a typical weed harvester ranges 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.

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 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 2016b).

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 (Engel 1995). 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 a USACE study that 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 (James et al. 2000).

8.6.10.2.33 Assess Risks to Listed Salmonids and sDPS Green Sturgeon

The proposed mechanical harvest and herbicide application program's normal period of application (June 28 through August 31) will substantially avoid the presence of listed salmonids in the Clifton Court Forebay 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 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 Clifton Court Forebay 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 Clifton Court Forebay under the Aquatic Weed Control Program will not affect the populations of 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, occurrence of fish in Clifton Court Forebay during the harvesting and/or herbicide treatments is not impossible. The numbers of CCV steelhead that may be potentially 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, the number of sDPS green sturgeon that reside in Clifton Court Forebay at any given time and their susceptibility to entrainment is also unknown. This uncertainty complicates the assessment of both population and individual exposure risks. This area of sDPS green sturgeon life history needs further resolution to make an accurate assessment of the impacts to the overall status of the population.

8.6.11 South Delta Agricultural Barrier Operations

DWR proposes to construct and operate three agricultural barriers in the channels of the south Delta each year, and Reclamation requests consultation on the construction and operation of these barriers through 2030. A separate biological opinion has been issued by NMFS for the construction effects of these barriers and their operations through 2022 to the U.S. Army Corps of Engineers. Two additional permits, the Incidental Take Permit and the Streambed Alteration

Agreement, were issued by CDFW for the construction and operations of the barriers and will expire in 2021. Finally, the section 401 Water Quality Certification from the Regional Water Quality Control Board for the south Delta barriers expires in 2022. DWR plans to re-initiate the permitting process for each of these permits prior to their expiration.

DWR constructs the three barriers in the south delta each spring to provide water surface elevation protection for south Delta agricultural diverters (ROC on LTO biological assessment, Appendix A (U.S. Bureau of Reclamation 2019c)). 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 each spring using large boulders and cobble, and have multiple steel culverts to allow the flow of water through the 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.

Construction of the agricultural barriers may begin on May 1 (Table A5-3, Appendix A (U.S. Bureau of Reclamation 2019c)). Closure of the barriers is typically completed by May 15 and the tidal flap gates 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. In addition, the barrier on Grant Line cannot be closed during this period if the Delta smelt incidental take concern limit has been reached. By June 1, both Old River and Middle River barriers can become fully functional and the flap gates left untied. The Grant Line barrier may still be left with the flap gates tied open if there are still Delta smelt incidental take issues. Finally, at least one culvert at each barrier will be kept open to allow for fish passage when water temperatures are less than 22ºC even if the previous conditions have been met.

Starting on September 15, 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. At the Grant Line barrier, the appropriate number of flashboards must be removed to provide for passage of adult fall-run Chinook salmon. By November 15, all barriers must be removed from their respective waterways.

Temporary agricultural barriers, constructed in the spring to provide water surface elevation protection for Delta agricultural diverters (U.S. Bureau of Reclamation 2019c), 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 biological assessment 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 U.S. Army Corps of Engineers, 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.

8.6.11.1 Assess Species Exposure to Proposed South Delta Agricultural Barrier Operations

8.6.11.1.1 Winter-run Chinook Salmon

Adult winter-run Chinook salmon do not spawn in the San Joaquin River basin and, therefore, are unlikely to be present in the location of the south Delta agricultural barriers during their construction and operations. Juvenile 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 to April. The Middle River and Old River at Tracy barriers are only 0.5 miles away from waterways known to contain juvenile winter-run Chinook salmon (Old River adjacent to the Tracy Fish Collection Facility, and Victoria Canal at the junction with Middle River). Because the proposed action does not include construction of the Head of Old River Barrier in the spring, construction of the barriers does not start until May 1. Therefore, it is unlikely that any juvenile winter-run Chinook salmon will be present in the waters of the south Delta during the construction and operations of the agricultural barriers.

8.6.11.1.2 CV 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 (see winter-run Chinook salmon section above), the presence of juvenile CV spring-run Chinook salmon during construction and operations of the barriers is assumed. 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 the barrier.

8.6.11.1.3 CCV 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 fall when the barriers are still in place prior to their removal by mid-November. 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.

8.6.11.1.4 sDPS 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 (see Figure 25), observations of sDPS green sturgeon have occurred year-round in this region.

8.6.11.2 Assess Response of Listed Salmonids

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). The report 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 predated 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 should encounter barriers with the notches in place (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.

Under the Proposed Action a portion of the fish from the San Joaquin Basin will route into Old River (Head of Old River) throughout the year at all Vernalis flows. Old River will experience higher velocities towards the export facilities and the San Joaquin River channel will experience lower velocities relative to actual current operations (though these results aren’t seen in the modeling results since neither the current operating scenario nor proposed action modeling scenario include spring installation of the Head of Old River Barrier). Reach-specific survival (from the Head of Old River to the export facilities) would be expected to improve in the Old River Channel and may decrease in the mainstem San Joaquin River. For purposes of comparing the proposed action to current operations in terms of the response of listed salmonids, NMFS has assessed effects in the south Delta relative to Head of Old River Barrier installation and operations.

Recent modeling of the effects of the head of Old River Barrier presence on the estimated CCV steelhead survival from the head of Old River to Chipps Island indicates that survival is higher when the barrier is installed, compared to when it is not installed (Buchanan 2019). The modeling was conducted using acoustic tag data from the six-year Steelhead Survival Study (2011-2016). The modeling used a generalized linear multinomial regression model to predict survival to Chipps Island as a function of San Joaquin River inflow at Vernalis, migration route taken by the CCV steelhead (Old River versus the mainstem San Joaquin River), and barrier status (installed versus not installed). The model used fixed year effects for the years with Delta inflow (Vernalis) that was less than 5,000 cfs (years 2012-2016 of the six-year study) and then combined over years in a weighted average using weights equal to the proportion of observations from each year used in the regression model.

Researchers found that when the Head of Old River Barrier is installed, the probability of total predicted survival from the Head of Old River to Chipps Island was estimated to range from 0.30 (SE = 0.20) for a Vernalis flow of 319 cfs to 0.67 (SE=0.20) for a Vernalis flow of 5,000 cfs (Buchanan 2019). When the barrier was not installed, the estimated predicted survival ranged from 0.17 (SE = 0.13) for a Vernalis flow of 319 cfs, to 0.50 (SE = 0.24) for a Vernalis flow of 5,000 cfs. The predicted difference in survival that was attributable to the presence of the barrier was estimated to range from 0.13 (SE = 0.08) for a Vernalis flow of 319 cfs to 0.19 (SE = 0.08) for a Vernalis flow of 3,889 cfs. Although there is high uncertainty in the predicted survival estimates for both conditions of the barrier's presence, and moderate uncertainty for the predicted effect of the barrier on survival, the predicted survival effect of the barrier (point estimate) was positive for all values of Delta inflows at Vernalis. The 95 percent confidence intervals excluded zero at flows above 783 cfs. The difference between survival estimates for the barrier installed and the barrier not installed were always positive for the point estimates. Buchanan (2019) cautions that this modeling is based on a limited data set (2011 to 2016). Additional years of data may change the weighting of years, and the yearly effects, as well as routing probabilities used in the preliminary regression model. In general, the current preliminary modeling results indicate that for flows below 5,000 cfs at Vernalis, survival for CCV steelhead emigrating from the San Joaquin River basin is higher when the Head of Old River Barrier is installed than when the Head of Old River Barrier is not installed.

Based on NMFS's current understanding of survival probabilities based on barrier condition at the Head of Old River, the proposed action will lead to lower survival of 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 by the South Delta Agricultural Barriers Effects Report (California Department of Water Resources 2018b) that 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 action creates conditions that would reduce steelhead survival to Chipps Island for the Southern Sierra Nevada Diversity Group.

8.6.11.3 Assess Response of sDPS 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. sDPS 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 swim upstream to the Head of Old River and access the main stem of the San Joaquin River to move back downstream into the Delta.

8.6.11.4 Assess Risk to Listed Salmonids

Both juvenile CV spring-run Chinook salmon and juvenile CCV steelhead will encounter the barriers when they are present in the channels of Old River, Middle River, and Grant Line Canal. The barriers will present a substantial impediment to downstream migration both as a physical structure, and as a source of mortality to individuals through predation. Delays in migration can also expose fish to elevated water temperatures as the season progresses, making any prolonged delay potentially lethal due to thermal tolerances of the fish.

8.6.11.5 Risk to Southern Distinct Population Segment Green Sturgeon

Both juvenile and adult sDPS green sturgeon will encounter the barriers when they are present in the channels of 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. It is unknown whether the barriers will increase predation on juvenile sDPS green sturgeon, or diminish their physiological status.

8.6.12 Conservation Measures

Reclamation included conservation measures as part of its proposed action to support listed species survival. These measures are assessed in this section.

8.6.12.1 Fall Delta Smelt Habitat

Ideal estuarine areas are free of migratory obstructions with water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh and salt water. Current estuarine areas are degraded as a result of the operations of the CVP and SWP. Historically, the Delta provided the transitional habitat for juvenile fish species to undergo the physiological change to salt water. However, as the location of the low salinity zone (X2) was modified to control Delta water quality, and competing species' needs (i.e., Delta smelt), the Delta served more as a migratory corridor for emigrating anadromous fish species.

Within the central and southern Delta, net water movement is towards the export facilities, altering the migratory cues for emigrating fish in these regions. Operations of upstream reservoir releases and diversion of water from the south Delta have been manipulated to maintain a "static" salinity profile in the western Delta near Chipps Island. This area of salinity transition, the low salinity zone, is an area of high productivity. Historically, this zone fluctuated in its location in relation to the outflow of water from the Delta and moved westwards with high Delta inflow (i.e., floods and spring runoff) and eastwards with reduced summer and fall flows. This variability in the salinity transition zone has been substantially reduced by the operations of the CVP and SWP. The CVP and SWP's long-term water diversions also have contributed to reductions in the phytoplankton and zooplankton populations in the Delta itself as well as alterations in nutrient cycling within the Delta ecosystem. Heavy urbanization and industrial actions have lowered water quality and introduced persistent contaminants to the sediments surrounding points of discharge (i.e., refineries in Suisun and San Pablo bays, creosote factories in Stockton, etc.).

The FWS' 2008 RPA provided a "Fall X2" standard which requires that the location of the low-salinity zone (defined as 2 parts per thousand (ppt) isohaline) be located at no greater than 46 and 50 miles (74 and 81 km) from the Golden Gate Bridge in September, October, and November of wet and above normal years, respectively, to improve rearing conditions for Delta Smelt. The low-salinity zone magnitude and dimensions change when river flows into the estuary are high, placing low-salinity water over a larger and more diverse set of nominal habitat types than occurs under low flow conditions. During periods of low outflow, the low-salinity zone contracts and moves upstream. Currently, in addition to D-1641, Reclamation operates to reduce entrainment risk and for Delta Smelt fall habitat in wet and above normal water years through releases of water from storage for Fall X2. The FWS recommended in its designation of critical habitat for the Delta Smelt that salinity in Suisun Bay should vary according to water year type. For the months of February through June, this element was codified by the State Water Resource Control Board's "X2 standard" described in D-1641 and the Board's current Water Quality Control Plan.

8.6.12.1.1 Deconstruct the Action - Fall Delta Smelt Habitat

Reclamation proposes to manage for Delta Smelt habitat in the fall of above normal and wet years by releasing additional Delta outflow to move the low salinity zone to beneficial areas to target creation of fall Delta smelt habitat in September and October following above normal and wet years. Fall Delta smelt habitat would be measured using the physical and biological features of critical habitat; mainly Secchi depth, chlorophyll, water temperature, and salinity. Reclamation would coordinate with FWS to assess the potential for updating the habitat index to incorporate biotic elements, in particular food (zooplankton prey density), in order to better capture the potential benefits from actions such as operation of the Roaring River Distribution System west-side drain. Achievement of these targets would be assessed using current multi-dimensional Delta models, applying the observed outflow and operations, in addition to other necessary inputs to be developed by Reclamation and DWR.

Reclamation proposes to operate the Suisun Marsh Salinity Control Gates for up to 60 additional days (not necessarily consecutive) from June 1 through October 31 of below normal and above normal, years. This action may also be implemented in wet years if preliminary analysis shows expected benefits Iterative analysis using the DSM2 model would be required to identify associated changes in Delta outflow and reservoir releases required to support changes in outflow. The analysis has not been completed and, therefore, the effects of this operation have not been incorporated in the CalSimII model.

The ROC on LTO biological assessment states that the proposed action would result in X2 being essentially the same as current operations in drier years, but greater (more upstream) than the current operations scenarios in wet and above normal years. Under the current operations scenario, X2 is at 86 km on average in September and 87 km on average in October. Under the proposed action component, according to the revised Delta Smelt Summer-Fall Habitat Chapter 4 (March 29, 2019 version), Delta outflow could be augmented in above normal or wet years to support a 2 ppt isohaline position of 80 km in September and October. During consultation Reclamation clarified the following:

> "As part of the Delta Smelt Habitat Action, Reclamation intends to meet Delta outflow augmentation in the fall primarily through export reductions as they are the operational control with the most flexibility in September and October of above normal and wet years. Storage releases from upstream reservoirs may be used to initiate the action by pushing the salinity out further in August and early September; however, the need for this initial action will depend on the particular hydrologic, tidal, storage, and demand conditions at the time. In addition, storage releases may be made in combination with export reductions during the fall period during high storage scenarios where near-term flood releases to meet flood control limitations are expected. In these scenarios, Reclamation will attempt to make releases in a manner that minimizes redd dewatering where possible. Additionally, Reclamation will consider an implementation strategy that minimizes upstream effects to listed species and is accounted for in the temperature management plans developed in the spring."

8.6.12.1.2 Assess Species Exposure to Fall Delta Smelt Habitat

The Delta waterways function primarily as migratory corridors for winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon, but it also provides holding and rearing habitat for each of these species. Juvenile salmonids may use the area for rearing for several months during the winter and spring before migrating to the marine environment. sDPS green sturgeon use the area for rearing and migration year-round. Generally, as flows increase in the fall and through the winter, adult salmon, steelhead, and green sturgeon migrate upstream through the Sacramento and San Joaquin rivers and juveniles migrate downstream in the winter and spring. Adult winter-run Chinook salmon typically migrate through the Delta between November and June with the peak occurring in March. Adult CV spring-run Chinook salmon migrate through the Delta between January and June. 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 they may also be found holding in waters of the Sacramento River basin and Delta year-round.

During the proposed Fall Delta Smelt Habitat time period, adult CCV steelhead are typically migrating upstream to spawning grounds in September and October. Juvenile and adult winter-run Chinook salmon and CV spring-run Chinook salmon, as well as juvenile CCV steelhead are unlikely to be present in the Delta at that time. Adult and juvenile sDPS green sturgeon are presumed to be present in the Delta year-round.

In contrast to the Delta region, waters below dams in the Central Valley that may be used to augment Delta outflows may contain various life stages of listed salmonids and sDPS green sturgeon. For example, the river reaches below Shasta and Keswick reservoirs in September and

October may contain incubating winter-run Chinook salmon eggs, newly hatched winter-run alevins, or winter-run Chinook salmon fry. In addition, there is the potential to have either adult spring-run Chinook salmon staging to spawn or already spawning, or adult CCV steelhead holding prior to their spawning activities later in the winter. Furthermore, the upper Sacramento River will also hold both adult and juvenile sDPS green sturgeon during the September and October period when water releases to augment Delta outflow may occur. The species and life stage affected by water releases for fall Delta outflow will depend on which reservoir is utilized to make those releases.

8.6.12.1.3 Assess Response of Listed Species to the Proposed Fall Delta Smelt Habitat

If Reclamation's proposed action component would augment Delta outflow with upstream reservoir releases, it could affect plans for water temperatures and flows below the reservoir releasing the water the remainder of the year. Releasing additional water from key reservoirs, such as Shasta Reservoir, to support Delta salinity criteria may deplete the cold water pool faster, and thus impact incubating eggs or larval winter-run Chinook salmon in the tail water reaches below Keswick Dam.

A change in Delta outflow or location of the low salinity zone can affect adult CCV steelhead and juvenile and adult sDPS green sturgeon during the fall, as adult CCV steelhead are migrating upstream at this time and sDPS green sturgeon may be migrating or rearing in the Delta. Increased Delta outflow may stimulate adult steelhead to initiate upstream migration earlier as it may resemble a precipitation event in the upper watershed. Changes in Delta outflow and the location of the low salinity mixing zone may influence the location of feeding for juvenile sDPS green sturgeon in the western Delta or influence outmigration of adult green sturgeon following spawning within the Sacramento River mainstem.

Since this aspect of the proposed action component can be implemented in various ways, effects to species or critical habitat are uncertain and will vary year to year and depending on how the outflow augmentation is implemented. Additionally, Reclamation will consider an implementation strategy that minimizes upstream effects to listed species and is accounted for in the temperature management plans developed in the spring.

8.6.12.1.4 Risk to Listed Salmonids and sDPS Green Sturgeon

Since adult CCV steelhead are typically migrating upstream to spawning grounds in the fall, and adult and sDPS green sturgeon may be present in the action area during the proposed action component, shifting the low salinity zone upstream for 2 months of the year is not likely to substantially alter food resources of other components that may affect listed salmonids or sDPS green sturgeon as they migrate through or rear in the area. No juvenile salmonids are expected to be present at this time, and adult CCV steelhead are entering from the ocean, traveling from a marine environment to freshwater.

Depending on potential changes to exports during the proposed Fall Delta Smelt Habitat action, there may be potential changes to listed fish species migration and survival if outflow is augmented with increased upstream reservoir releases. This could affect plans for water temperatures and flow volumes in both upper river locations and within the Delta. As stated previously, depending on the reservoir making releases to support Delta X2 criteria, different ESUs and DPSs of listed salmonids may be affected. For example, releases made from Shasta

Reservoir in September and October may impact eggs and larval winter-run Chinook salmon still in the gravel, and juveniles rearing in the upper Sacramento River below Keswick Dam by depleting the cold water pool necessary for their survival. Since this aspect of the proposed action component can be implemented in various ways, effects to species or critical habitat are uncertain and will vary year to year and depending on how the outflow augmentation is implemented. Reclamation will attempt to make releases in a manner that minimizes redd dewatering where possible. Additionally, Reclamation will consider an implementation strategy that minimizes upstream effects to listed species and is accounted for in the temperature management plans developed in the spring.

8.6.12.2 Sacramento Deep Water Ship Channel Food Study

The Sacramento Deep Water Ship Channel (SDWSC) is a 43-mile long artificial channel created in 1963 to allow passage of ocean going vessels from Suisun Bay to the Port of Sacramento in West Sacramento. It begins at river mile 0 of the Sacramento River and ends at a navigation lock in West Sacramento between the Sacramento River and the SDWSC. It consists of two sections, Suisun Bay to Cache Slough (lower section), and Cache Slough to West Sacramento (upper section). The upper section consists of the ship channel, a triangular harbor and turning basin called Washington Lake, and a barge canal and navigation lock. The W.G. Stone Lock connects the SDWSC to the Sacramento River via the SDWSC barge channel near Sacramento river mile 57 for transfer of barges between waterways.

Due to the infrequent usage in the 1980s and 1990s, the lock was de-authorized in 2000, and currently remains in a closed position. However, there is a small amount of water leakage through the lock gate seals. Water exchanges in the SDWSC currently are driven by tidal action. The lack of flow has led to poor water quality conditions, when compared to surrounding areas, conditions in the SDWSC include high salinity and water temperatures, and low dissolved oxygen (Department of Water Resources 2019).

Although discontinued use of the lock has likely reduced the attraction of salmonids to the upper SDWSC, a limited, yet unknown number of fish, currently enter the channel and are observed staging below the locks. The survival of salmon and steelhead that migrate into the upper SDWSC is not known. Prior to ceasing lock gate operations, fish could pass through the open gates and enter the Sacramento River. Salmon and steelhead that are blocked behind the closed lock gates are thought to be harvested by anglers or die without spawning.

Juvenile salmonids are unlikely to enter the SDWSC from the Sacramento River during their emigration due to the limited flow that enters the SDWSC.

There is a lack of riparian vegetation and large woody debris along the linear ship channel. Emergent aquatic vegetation, comprised of bulrush cattail and three-square bulrush grows sporadically along the edge of the channel; grasses and forbs grow along the levee slopes. Most of the shoreline is covered with riprap or maintained through vegetation removal and rock applications.

8.6.12.2.1 Deconstruct the Action - Proposed Operations of Sacramento Deep Water Ship Channel Food Study

Reclamation proposes to repair or replace the West Sacramento lock system to hydrologically reconnect the SDWSC with the mainstem of the Sacramento River from mid-spring to late-fall for the purpose of flushing food production into the north Delta to benefit Delta smelt and to provide an alternate migration pathway for fish. Reclamation states that the proposed action component could result in positive effects on subadult Delta smelt during early fall (U.S. Bureau of Reclamation 2019c). The efficacy of the proposed action component has yet to be tested with pilot studies.

In order to re-operate the lock gates, NMFS assumes construction would be required. Since this is a programmatic action, no specific details of construction activity, timing of lock gate operation, or the portion of Sacramento River flow that would be diverted into the SDWSC were provided at this time. Therefore, only a generalized assessment of effects can be assessed based on fish and water moving through the SDWSC during gate operations.

8.6.12.2.2 Assess Species Exposure to Proposed Sacramento Deep Water Ship Channel Food Study

Estimates of the number of salmon, CCV steelhead, and sDPS green sturgeon that enter the SDWSC is unknown. However, Chinook salmon and steelhead are known to have previously migrated through the SDWSC prior to their upstream passage being blocked by the W.G. Stone Locks. Adult Chinook salmon likely migrate into the upper SDWSC and hold below the W.G. Stone Lock, possibly attracted to the small of amount of Sacramento River water leaking through an 8-inch crack in the gates. Known species migration timing indicates that adult Chinook salmon may migrate upstream primarily during spring months and are likely blocked by the lock throughout the summer and fall months, and may be present year-round.

Adult winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and the sDPS green sturgeon migrate through the Sacramento-San Joaquin Delta waterways on their way to spawning grounds. The Delta also provides holding and rearing habitats for each of these species as they emigrate as juveniles. Juvenile salmonids may use the area for rearing for several months during the winter and spring before migrating to the marine environment. sDPS green sturgeon use the area for rearing and migration year-round. All four species are likely to be present in the Delta or Sacramento River during part of all of the mid-spring to late-fall time period, and therefore would be exposed to the proposed action. Reconnecting the SDWSC to the Sacramento River would allow part of the river to flow through the SDWSC potentially improving some water quality parameters. The proposed action component could also increase the mobilization of accumulated sediment in the channel, which could contain historical pesticides or other contaminants, possibly affecting listed fish species present in the SDWSC or downstream.

Assuming that the repair or replacement of the lock system would involve construction activities such as dredging and pile driving, effects from suspended sediment and noise would be expected, and would likely include decreased dissolved oxygen, increased turbidity, and mobilization of toxic chemicals, according to the Central Valley Regional Water Quality Control Board basin plan (California Regional Water Quality Control Board 2018). Since detailed construction activities were not provided to NMFS, effects to species from construction activities could not be analyzed at this time.

8.6.12.2.3 Assess Response of Species to the Proposed Sacramento Deep Water Ship Channel Food Study

Estimates of the number of adult salmon, CCV steelhead, and sDPS green sturgeon that enter the SDWSC and follow it upstream to the lock is unknown. However, existing information indicates that adult Chinook salmon and steelhead migrate into the SDWSC and their upstream passage is blocked by the W.G. Stone Locks. Re-opening the gates may allow adult salmonids and potentially sDPS green sturgeon to migrate between the Sacramento River and SDWSC, which would likely benefit fish that would otherwise be blocked. An increase in flow through the SDWSC may also cause a false attraction for adult salmonids and sDPS green sturgeon, leading to more adults entering the SDWSC rather than migrating up their natural route through the Sacramento River.

Allowing flow to enter the SDWSC from the Sacramento River during times of year when juvenile salmonids are outmigrating, may change their route, taking them through the SDWSC rather than through their natural migration route down the Sacramento River. Survival in the SDWSC in unknown, however, it would likely result in decreased survival, due to potential predation and lack of suitable rearing habitat. In-channel large woody debris and shaded riverine aquatic (SRA) habitats are important components for rearing salmonids because they contribute to shade, food production, and cover from predators. The sparse and sporadic distribution of these habitats, in addition to mobilizing potentially contaminated sediment in the SDWSC, limit the value of the channel as rearing habitat for salmon, CCV steelhead, and sDPS green sturgeon.

Opening the W.G. Stone Locks would facilitate the upstream passage of adult salmonids and sDPS green sturgeon, but may also divert juvenile salmon and sDPS green sturgeon from the Sacramento River downstream into the SDWSC. Closing or opening the gates may attract increased numbers of adult salmon and sDPS green sturgeon upstream into the SDWSC which may become trapped or delayed behind the gates when they are closed. The primary factors affecting the species' survival within the SDWSC include freshwater flows through the lock, tidal exchange, water temperatures, water quality, riparian habitat, angler harvest, and predation. ESA-listed fish species may be affected by creating false attraction flows, blocking adult salmon and sDPS green sturgeon behind the lock gates, creating unfavorable juvenile outmigration conditions, and reducing the number of individuals that escape to the Pacific Ocean or migrate upriver to spawn. Furthermore, an additional risk for adult sDPS green sturgeon is the vulnerability of vessel strikes from large ocean going vessels transiting the SDWSC while traveling to or from the Port of Sacramento.

Potential effects from construction activity may include temporary effects from increased turbidity, decreased dissolved oxygen, and pile driving activities. Since detailed activities were not provided, effects to fish are not analyzed at this time.

8.6.12.3 North Delta Food Subsidies / Food Subsidy Studies

The Colusa Basin drain, located near the town of Dunnigan, California, provides drainage for surface runoff as well as agricultural discharge. The drain also serves as a water source for irrigation users. In the fall, during high irrigation use, water flows from the Colusa Basin drain through Knights Landing outfall gates into the Sacramento River or into Yolo Bypass.

Suisun Marsh is a large brackish marsh area that is part of the San Francisco Bay tidal estuary. It is formed primarily by the confluence of the Sacramento and San Joaquin rivers between Martinez and Suisun City, California. The Suisun Marsh facilities are jointly operated by the CVP and SWP, and include the Suisun Marsh Salinity Control Gates, Roaring River Distribution System (RRDS), Morrow Island Distribution System (MIDS), and Goodyear Slough Outfall.

The Suisun Marsh Salinity Control Gates are located on Montezuma Slough about 2 miles downstream of the confluence of the Sacramento and San Joaquin rivers, near Collinsville, California. The purpose of gate operation is to decrease the salinity of the water in Montezuma Slough to meet salinity standards set by the State Water Resource Control Board and Suisun Marsh Preservation Agreement. The Suisun Marsh Salinity Control Gates control salinity by lowering gates during flood tides to prevent 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, Suisun Marsh Salinity Control Gates operation occurs from October to May (~10-20 days) 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. Outside of the period, the radial gates remain open, flashboards are removed, and operation of the boat lock is not needed. As of 2018, gates are operated during August in "below normal" or "above normal" water years in addition to October to May operation.

Roaring River Distribution System is located north of Honker Bay. The RRDS diverts water from Montezuma Slough through a bank of eight 60-inch-diameter culverts. RRDS is equipped with fish screens into the Roaring River intake pond during high tides, in order to raise the water surface elevation in RRDS above the adjacent managed wetlands. Managed wetlands north and south of the RRDS receive water, as needed, through publicly and privately owned turnouts on the system.

8.6.12.3.1 North Delta Food Subsidies / Colusa Basin Drain

Reclamation proposes to increase food entering the north Delta through flushing nutrients from the Colusa Basin into the Yolo Bypass and north Delta. DWR, Reclamation, and water users would work with partners to flush agricultural drainage water from the Colusa Basin Drain through Knights Landing Ridge Cut and the Tule Canal to Cache Slough, to potentially increase aquatic food resources in the north Delta for fish. Reclamation would work with DWR and partners to augment flow in the Yolo Bypass in July and/or September by closing Knights Landing Outfall Gates and routing water from Colusa Basin into Yolo Bypass to promote food production for fish. Under the proposed action component, approximately 24,000 acre-feet (AF) of agricultural water would be diverted over a 4-week period (during July, August, and/or September) from Colusa Basin into Yolo Bypass rather than out falling into the Sacramento River. This would result in increased flow in Yolo Bypass during late summer. The ROC on LTO biological assessment does not provide sufficient detail to conduct an in-depth effects assessment for this proposed action component. Therefore, the assessment of proposed action effects will be a very high level overview of this proposed action component and not adequate for a full consultation. Therefore, this proposed action component will be considered as a programmatic consultation.

8.6.12.3.2 Suisun Marsh Food Subsidies

Reclamation proposes to increase food production for fish in Suisun Marsh through coordinating managed wetland flood and drain operations in Suisun Marsh, RRDS food production, and reoperation of the Suisun Marsh Salinity Control Gates in June through September in above normal and below normal years. As noted in the Delta Smelt Resiliency Strategy, the purpose of this management action is to attract Delta smelt into the high-quality Suisun Marsh habitat, reducing use of the less food-rich Suisun Bay habitat (California National Resources Agency 2016). Infrastructure in the RRDS would be used to help drain food-rich water from the canal into Grizzly Bay to potentially augment Delta smelt food supplies in that area.

In addition to the current October through May operation to meet Suisun Marsh water quality standards, Reclamation proposes operating the Suisun Marsh Salinity Control Gates on the tidal cycle in below normal and above normal years in June through September for 60 days, not necessarily consecutive, to improve Delta smelt critical habitat. Under the proposed action component, Reclamation and DWR would increase tidal operations of the Suisun Marsh Salinity Control Gates to direct more fresh water in Suisun Marsh to reduce salinity, increase food, and improve habitat conditions for Delta smelt. In addition to current operation, Suisun Marsh Salinity Control Gates would operate in June to September in above normal and below normal years. This would be combined with RRDS management for food production and flushing freshwater through the RRDS to increase the low salinity habitat in Grizzly and Honker bays. Reclamation and DWR will continue to meet existing D-1641 salinity requirements in the Delta and Suisun Marsh. The ROC on LTO biological assessment does not provide sufficient detail to conduct an in-depth effects assessment for this proposed action component. Therefore, the assessment of proposed action effects will be a very high level overview of this proposed action component and not adequate for a full consultation. Therefore, this proposed action component will be considered as a programmatic consultation.

8.6.12.3.3 Assess Species Exposure to Proposed Food Subsidies

Reclamation proposes to route approximately 24,000 AF of agricultural water through the Colusa Basin Drain to the Cache Slough area through the Yolo Bypass during the months of July to September. The timing of observations of listed species in the Delta are determined by Delta Juvenile Fish Monitoring Program (U.S. Fish and Wildlife Service 2014; U.S. Fish and Wildlife Service 2015b; U.S. Fish and Wildlife Service 2016a; U.S. Fish and Wildlife Service 2017), which conducts annual monitoring of fishes to determine abundance and distribution of juvenile salmonids and other species. According to Delta Juvenile Fish Monitoring Program data, juvenile winter-run Chinook salmon are primarily present in the Delta from November to April, juvenile CV spring-run Chinook salmon are present primarily from December through May, and juvenile CCV steelhead were determined to be present in the Delta primarily from December to July. According to Delta Juvenile Fish Monitoring Program and salvage data, and sDPS green sturgeon are present year-round.

Adult winter-run Chinook salmon are present in the Delta from November to June as they migrate from the ocean up the Sacramento River to their spawning grounds. Adult CV spring-run

Chinook salmon are present in the Delta from January through June (California Department of Fish and Game 1998; Moyle 2002; Yoshiyama et al. 1998). Adult CCV steelhead are present in the Delta from August to October on their way to the northern Central Valley tributaries (Moyle 2002), and from March to May on their return to the ocean (Hallock et al. 1961). For San Joaquin River origin fish, adult CCV steelhead peak in November through January (California Department of Fish and Game 2007). There are limited data on the residence time and run timing of adult CCV steelhead of both Sacramento and San Joaquin River origin in the Delta. Adult sDPS green sturgeon may be present in the Delta during all months of the year (Heublein et al. 2009; Moyle et al. 1995).

8.6.12.3.4 Assess Response of Listed Species to the Proposed Food Subsidies

The proposed action component has the potential to increase the exposure of fish to harmful contaminants through diversion of agricultural drainage into the Sacramento River. Chemical forms of water pollution are a major cause of freshwater habitat degradation worldwide. There are many sources of contaminants, and these reflect past and present human activities and land use (Scholz and McIntyre 2015). Contaminants are typically associated with areas of urban development, agriculture, or other anthropogenic activities. Organic contaminants from agricultural drain water, urban and agricultural runoff from storm events, and high trace element (i.e., heavy metals) concentrations may have deleteriously effects on survival of fish in the Central Valley watersheds.

One of the contaminants potentially present is selenium, which was identified as one of the pollutants in San Francisco Bay and the western Delta on the Clean Water Act section 303(d) list (State Water Resources Control Board 2010a). Within the Delta, there are multiple sources of selenium. Presser and Luoma (2013) identify oil refinery wastewaters from processing crude oils at North Bay refineries and irrigation drainage from agricultural lands in the western San Joaquin Valley (mainly via the San Joaquin River) as the two primary sources. Agricultural drainage in the Sacramento Valley west-side creeks in the Yolo Bypass and non-oil industries and wastewater treatment effluents are minor sources of selenium in the Delta. Selenium can elicit a short- and long-term response from aquatic biota depending on the quantity, quality, and duration of selenium exposure. The primary exposure pathway for fish and other aquatic organisms to selenium is through their diet (Presser and Luoma 2010a; Presser and Luoma 2010b; Presser and Luoma 2013; Stewart et al. 2004). Continued exposure of selenium can result in bioaccumulation and/or toxicity to fish in the Delta. Because adult salmon and steelhead do not forage extensively while in the Delta before spawning upstream in the rivers (Sasaki 1966), their exposure is likely to be much less than exposure for juveniles, which spend most of their time in the Delta feeding and foraging for food. Thus, survival and growth of juvenile salmonids may be affected by potential contaminant exposure, due to the timing in which those juveniles occur and feed within the action area. sDPS green sturgeon migrate from major rivers to the Delta and reside within the Delta or in the Pacific Ocean (U.S. Fish and Wildlife Service 2008). Therefore, all life stages of sturgeon have the potential to be exposed to contaminants in the Delta.

At Suisun Marsh, the Suisun Marsh Salinity Control Gates would be operated for 60 days in June to September in above normal and below normal years and up to 20 days during October to May. Suisun Marsh Salinity Control Gates would be operated for a total of up to 80 days year-round, primarily during summer months. NMFS assumes the boat lock would remain in the open position during operation, allowing fish passage when gates are closed. Operation of the Suisun Marsh Salinity Control Gates from October through May coincides with the upstream migration of adult Central Valley anadromous salmonids and sDPS green sturgeon. The late winter and spring downstream migration of Central Valley salmonids also overlaps with the operational period of the Suisun Marsh Salinity Control Gates. During summer operations, juvenile and adult CCV steelhead and sDPS green sturgeon are present in the Delta, and potentially adult winter-run Chinook salmon and CV spring-run Chinook salmon during June. During the majority of the year, the Suisun Marsh Salinity Control Gates will not be operated and no fish passage delays due to the gates are anticipated. However, during the annual 70 to 80 days of periodic operation, individual adult salmonids and sDPS green sturgeon may be delayed in their spawning migration from a few hours to several days. 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. sDPS 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 adult green sturgeon to linger for several days in the Delta prior to initiating their active direction migration to the upper Sacramento River (Vogel 2008).

8.6.12.3.5 Assess Risk to Listed Fish Species

ESA-listed fish species that are most likely to be present during the North Delta Food Subsidies/ Colusa Basin Drain proposed action component include juvenile and adult sDPS green sturgeon and adult CCV steelhead. Since the proposed action component includes diversions that would occur during the summer and early fall, most ESA-listed species are unlikely to be present in the Yolo Basin, Tule Canal, Toe Drain, or Cache Slough complex during this period of time. However, the project description does not provide specific details such as expected changes to water temperature or contaminant load of the diverted agricultural water and therefore, impacts cannot be fully analyzed at this time. Only generalized impacts will be considered in this analysis. This proposed action component will be considered as a programmatic consultation.

The proposed Suisun Marsh Food Subsidies action could affect all four listed species present in the Suisun Marsh, Suisun Bay, Grizzly Bay, and Honker Bay since Suisun Marsh Salinity Control Gates operation would occur year-round, however, operation would only occur up to 80 days of the year.

Migrating salmonids and sDPS green sturgeon may be affected by the operation of the Suisun Marsh Salinity Control Gates, as it may delay their movement. If the Suisun Marsh Salinity Control Gates are in operation, the gates will open and close twice each day with the tides. On the ebb tide, the gates are open and fish will pass downstream into Montezuma Slough without restriction. On the flood tide, the gates are closed and freshwater flow and the passage of juvenile fish will be restricted. Salmonid smolt predation by striped bass and pikeminnow could be exacerbated by operation of the Suisun Marsh Salinity Control Gates since these predatory fish are known to congregate in areas where prey species can be easily ambushed. However, operation of the Suisun Marsh Salinity Control Gates would be limited to only periods required for compliance with salinity control standards, and this operational frequency is expected to be no more than 80 days per year, mostly during summer months when smolts are unlikely to be present. Therefore, the Suisun Marsh Salinity Control Gates will not provide the stable environment which favors the establishment of a local predatory fish population and the facility is not expected to support conditions for an unusually large population of striped bass and pikeminnow. In addition, most listed Central Valley salmonid smolts reach the Delta as yearlings or older fish.

The project description did not include specific details on water quality in the Colusa Basin Drain or whether the Suisun Marsh Salinity Control Gates boat lock would be open during operation or when the flashboards would be installed and removed. In order to fully assess impacts of the proposed action to ESA-listed fish species for the North Delta and Suisun Marsh Salinity Control Gates Food Studies, more information should be provided. Therefore, this proposed action component will be considered a programmatic consultation.

8.6.12.4 Habitat Restoration in the Bay/Delta

All ESA-listed salmonids and 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 winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon are expected to be exposed to 8,000 acres of tidal habitat restoration in the Delta. The proposed action includes completion of the remaining 6,000 acres of tidal habitat restoration and increased acreage of seasonal floodplain rearing habitat in the lower Sacramento River basin (Yolo Bypass) by 2030. Habitat restoration is expected to benefit juvenile winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and southern DPS green sturgeon in several aspects, including 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 in-water construction work window for tidal and channel margin restoration under the proposed action component is August–October. The following life stages of the listed salmonids and sDPS 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 winter-run Chinook salmon, CV spring-run Chinook salmon, or CCV steelhead are expected to be present during the in-water construction work window. Reclamation lists the following potential effects to listed salmonids and sDPS green sturgeon from construction of restoration projects in the ROC on LTO biological assessment (U.S. Bureau of Reclamation 2019c):

> *"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 and 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 application of avoidance and minimization measures (Appendix E, Avoidance and Minimization Measures)."

Reclamation also states in the ROC on LTO biological assessment that "Reclamation and DWR will consult on future tidal habitat restoration with FWS and NMFS on potential effects to fish from construction-related effects." Due to the lack of specifics project elements and details regarding implementation, and success criteria, this proposed action component will be considered as a programmatic consultation.

8.6.12.5 Sediment Supplementation Feasiblity Study

Reclamation proposes to develop and implement a sediment supplementation feasibility study. The goal of this study will be to determine methods to reintroduce sediment in the Delta to increase turbidity which would provide better habitat conditions for all life stages of delta smelt. This study will include, at minimum, consideration of sediment placement upstream of the Delta during low flow periods, followed by sediment remobilization following inundation during seasonal high flows.

Increased turbidity has the potential to impact salmonids during juvenile and adult life stages present in the Delta. Specifically, increased turbidity can clog or abrade gill surfaces,and cause stress responses such as gill flaring, coughing, avoidance, and increased blood sugar levels (Berg and Northcote 1985; Servizi and Martens 1992). Increased sediment concentrations can also affect fish by reducing feeding efficiency or success and stimulating behavioral changes. However, because the mobilization of sediments as a result of this work would be ephemeral and only occur during seasonal high flows, long-term exposure to these effects is unlikely. Increased turbidity can also provide a level of cover from predators for outmigrating juveniles and contribute to higher levels of juvenile survival. Turbidity has been shown to reduce the risk of predation and improve the survival of emigrating Pacific salmon in many rivers (Gregory and Levings 1998).

Due to the lack of specifics project elements and details regarding implementation, and success criteria, this proposed action component will be considered as a programmatic consultation.

8.6.12.6 Predator Hot Spot Removal

Predator hot spot removal under the proposed action component (April 30, 2019; (U.S. Bureau of Reclamation 2019a)) is intended to improve conditions for downstream-migrating juvenile salmonids, including winter-run Chinook salmon, CV spring-run Chinook salmon, and CCV steelhead. The proposed action component may focus removal efforts where predators are likely concentrated along the primary migratory routes of juvenile Chinook salmon (e.g., hotspots identified by Grossman et al. (2013)). However, implementation of the proposed action component could also improve conditions for all life stages of CCV steelhead and potentially juvenile sDPS green sturgeon emigrating downstream. The ultimate effect of predator hotspot removal on juvenile salmonid and sDPS green sturgeon survival is uncertain. Hotspots are limited in scale relative to overall available habitat and previous research has not found a consistent positive effect of predator removal on juvenile salmon survival (Cavallo et al. 2012; Michel et al. 2015; Sabal et al. 2016). In general, there is a lack of detail and specificity in the biological assessment to conduct a thorough effects analysis for this proposed action component.

Analysis of the proposed action component effects are general in nature and will be considered as a programmatic consultation.

8.6.12.6.1 Deconstruction of the Predator Hot Spot Removal

Reclamation proposes to remove potential predator hot spots that occur in waters of the Delta. These hot spots may include in-water structures such as abandoned docks, outfalls, pump platforms, or pilings, removing overhead lighting at bridges and fish screens that illuminate the water surface at night, or filling in scour holes or other anomalies in the bathymetry that attract predators. The ROC on LTO biological assessment does not identify exact locations or the process that will be undertaken to remove these predator hotspots.

8.6.12.6.2 Assess Exposure of Listed Species to Predator Hot Spot Removal

In-water construction at predator hot spot removal locations in the lower Sacramento River and Bay/Delta is proposed to occur during the in-water work windows through the summer months, when juvenile listed salmonids are generally still located in the upper river sections of the Sacramento River and San Joaquin River basins. However, the starting and endpoints for the in-water work window were not defined in the biological assessment. Based on the summer in-water work window, construction actions at hot spot locations are not anticipated to effect juvenile salmonids but could occur when rearing juvenile sDPS green sturgeon are present, due to the year-round use of the Delta by juvenile sDPS green sturgeon for rearing. In addition, hot pockets of predation in the northern Delta could overlap with the presence of adult CCV steelhead, which are migrating through the system in large numbers from August through November.

8.6.12.6.3 Assess Response of Listed Salmonids to Predator Hot Spot Removal

Since the ROC on LTO biological assessment has not described the methods proposed to remove predator hot spots, it is difficult to assess the response of listed salmonids or sDPS green sturgeon to these actions. NMFS anticipates that heavy construction actions will need to take place to remove structures or pilings in the water, as well as to fill in scour holes or other bathymetry anomalies that attract predators. Typically, heavy construction actions create noise and vibrations in the surrounding aquatic environment that will disturb any fish located in the proximity of the action. Filling in scour holes, typically with some sort of rock substrate, may entail potential crushing or injuries due to the dumping of fill materials into the water column. Normally, any fish present at the onset of such construction activities will leave the location of the disturbance and thus avoid any negative effects.

8.6.12.6.4 Response of Southern Distinct Population Segment Green

Although details of the proposed action components for this action are minimal, NMFS anticipates that responses of sDPS green sturgeon to construction related actions to remove predator hotspots will be similar to listed salmonids. Individuals from the sDPS green sturgeon population may be more susceptible to the construction related actions to remove predator hot spots in the Bay/Delta region due to their year-round presence in the Delta. Elevated construction activity is anticipated to drive sDPS green sturgeon away from areas of the predator hot spot removal as individuals attempt to avoid disturbances in the aquatic environment. As stated previously, the lack of detail in the ROC on LTO biological assessment regarding the predator hot spot action limits the assessment of effects to listed sDPS green sturgeon.

8.6.12.6.5 Assess Risk to Listed Salmonids from Predator Hot Spot Removal

NMFS anticipates that there will be low risk to juvenile listed salmonids associated with the removal of predator hot spots due to the timing of such work. Juvenile listed salmonids are expected to be upriver of the Delta during the summer, and thus will not be exposed to any of the construction actions required to remove identified predator hot spots in the Delta. On the other hand, adult CCV steelhead migrating into the Sacramento River basin may be exposed to the effects of any construction actions required to remove predator hot spots. These fish may be exposed to increased levels of sound, vibrations, or activities along the banks of migratory channels. In most instances, these disturbances will potentially cause migratory delays, or re-routing of fish into migratory pathways with less activity. In the most extreme cases, exposure to the construction activities could cause injury or death. Implementation of the proposed avoidance and minimization measures will reduce the level of risk associated with the construction actions. After removal of in-water structures or other features that create predator hotspots, migratory success of juvenile salmonids should be enhanced. However, the improvement may be transitory or less than anticipated due to the behavior of predators, and the potential that predators would move to adjacent habitat. It should be noted that the lack of detail in the description of this proposed action component limits the level of detail in assessing the risk to listed salmonids. Therefore, this proposed action component will be considered as a programmatic consultation.

8.6.12.6.6 Risk to Southern Distinct Population Segment Green Sturgeon

NMFS anticipates that overall there will be a low to medium risk to juvenile sDPS green sturgeon associated with the removal of predator hot spots in the Delta due to the distribution of individual green sturgeon across the Delta. The greatest risk will come from activities that fill in scour holes or other bathymetric anomalies that attract predators. Such habitat would also tend to attract sDPS green sturgeon due to the increased water depth, thus providing a higher level of overlap between the presence of sDPS green sturgeon and the activities associated with predator hot spot removal. However, the biological assessment does not identify the numbers or locations of such deep water habitat that would be identified as a predator hot spot, thus providing a detailed assessment of the level of risk is not possible. This proposed action component will be considered as a programmatic consultation.

8.6.12.6.7 Address scour hole at Head of Old River

The final proposed action describes this action as follows:

- "Reclamation and DWR would form a project team to address the scour hole in the San Joaquin River at the Head of Old River. The project team would plan and implement measures to reduce the predation intensity at that site through modifications to the channel geometry and associated habitats."

Reducing predation at the scour hole in the San Joaquin River at the Head of Old River is a specific example of the conservation measure in the original proposed action to "remove predator hot spots in the Bay-Delta", described in Section 8.6.12.6. The effects are expected to be as described there, with benefits most likely accruing to CCV steelhead and CV spring-run Chinook salmon entering the Delta from the San Joaquin River.

8.6.12.7 Reintroduction efforts from Fish Conservation and Culture Laboratory

The existing Fish Conservation and Culture Laboratory located adjacent to the Skinner Delta Fish Protective Facility at the SWP will be used to begin Delta smelt production to supplement the natural Delta smelt population. Information developed through the operations of the Fish Conservation and Culture Laboratory will be used to create a supplementation strategy and inform the construction of the new conservation hatchery. The culture of Delta smelt at the Fish Conservation and Culture Laboratory does not utilize or expose any listed salmonid or sDPS green sturgeon to capture or handling. The facility is located outside of designated critical habitat for CCV steelhead and sDPS green sturgeon on the inlet channel to the Banks Pumping Plant of the SWP. NMFS does not expect that the release of cultured Delta smelt back into the Delta, its historical native habitat, will have any negative impacts on listed salmonids or sDPS green sturgeon present in the Delta.

8.6.12.8 Delta Fish Species Conservation Hatchery

The operation of the Delta Fish Species Conservation Hatchery would not provide benefits to any life stage of winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, or sDPS green sturgeon. Potential negative effects of the Delta Fish Species Conservation Hatchery include inadvertent propagation and spread of invasive or nuisance species, which could affect listed salmonids and sDPS green sturgeon through changes in food web structure. Additional impacts could include reduced water quality resulting from hatchery discharge. Potential negative effects from discharged water are expected to be minimal due to the water sterilization treatments for pathogens and invasive species and the very small size of the discharge compared to flows in the Sacramento River near the hatchery location. Mitigation and minimization measures detailed in the EIR/EIS for the facility (Horizon Water and Environment 2017) indicate that potential impacts are less than significant. Potential exposure of juvenile winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon would be restricted to a small spatial area within the primary migration route and rearing habitat where effluent from the Delta Fish Species Conservation Hatchery discharges into the Sacramento River.

As with the other proposed construction activities in the Bay-Delta, few if any juvenile winter-run Chinook salmon, CV spring-run Chinook salmon, or CCV steelhead would be expected to be exposed to the effects of construction of the Delta Fishes Species Conservation Hatchery based on the timing of in-water construction (August–October) and the typical seasonal occurrence of these fish in the Delta. There may be some exposure of early or late migrating juvenile salmonids to in-water and shoreline construction of the hatchery intake and outfall. The year-round occurrence of juvenile sDPS green sturgeon in the Delta means that this life stage, as well as adult sDPS green sturgeon occurring in the Delta during May to October, could be exposed to Delta Fish Species Conservation Hatchery construction under the proposed action component. Individuals occurring near the construction site could be subject to effects similar to those previously described for habitat restoration (e.g., temporary loss of habitat leading to predation, degraded water quality, reduced foraging ability caused by reduced visibility, noise-related delay in migration, and direct effects from contact with construction equipment or isolation/stranding within enclosed areas). The risk from these potential effects would be minimized through application of avoidance and minimization measures (U.S. Bureau of Reclamation 2019c). There is low potential for exposure because of the in-water work window, the application of avoidance and minimization measures, and the small scale of the in-water construction. However due to the lack of specific plans and construction schedule that may require years to complete the facility, a full effects analysis cannot be conducted. Therefore, this proposed action component will be considered as a programmatic consultation.

8.6.12.9 State Steelhead Lifecycle Monitoring Program and San Joaquin Basin Steelhead Collaborative

The final proposed action included the following items:

- *Steelhead Lifecycle Monitoring Program*: Develop infrastructure that will support a functioning life cycle monitoring program in the Stanislaus River and a Sacramento basin CVP tributary (e.g. Clear Creek, Upper Sacramento, American River) to evaluate how actions related to stream flow enhancement, habitat restoration, and/or water export restrictions affect biological outcomes including population abundance, age structure, growth and smoltification rates, and anadromy and adaptive potential in these populations. The goal of this monitoring program will be to improve understanding of steelhead demographics and, when combined with other steelhead-focused parts of the proposed action (San Joaquin and Delta steelhead telemetry study), inform actions that will increase steelhead abundance and improve steelhead survival through the Delta.
- *San Joaquin Basin Steelhead Collaborative*: Within 1 year, Reclamation will coordinate with CSAMP to sponsor a workshop for developing a plan to monitor steelhead populations within the San Joaquin Basin and/or the San Joaquin River downstream of the confluence of the Stanislaus River, including steelhead and rainbow trout on non-project San Joaquin tributaries. The plan would be delivered to the IEP for prioritization and implementation, where feasible, for actions within the responsibility of the CVP and SWP and other members of the IEP. If the IEP is not able to implement the plan, the plan may be raised at the Director Level Collaborative Planning Meeting described under the "Governance" section of this proposed action for resolution.

NMFS supports both of these efforts to get better information about CCV steelhead which may inform development of beneficial actions to increase steelhead abundance or survival. NMFS considers both items to be programmatic consultations.

8.6.13 Division Effects Summary

The following tables summarize the project-related stressors for each species and component of the proposed action. The 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.

8.6.13.1 Sacramento-River Winter-Run Chinook salmon

Table 106. Summary of Bay-Delta Division operations related effects to Sacramento River winter-run Chinook salmon.

Action Component	Life Stage	Stressor/ Factor	Individual Response and Rationale of Effect[16]	Severity of Stressor/ Level of Benefit	Proportion of Population Exposed[17]	Frequency of Exposure	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness
Delta Smelt Summer-Fall Habitat	Eggs/Fry	Temperature	Temperatures higher than 53.5°F would result in egg/fry mortality	uncertain but possibly sublethal to lethal if not carried out through export reductions and action is met through Shasta release	Medium - Large	Low	Medium	Low	Decreased survival of eggs/fry exposed to temperatures above 53.5°F
Fall Delta smelt habitat	Juveniles	Habitat management	Management of salinity mixing zone to benefit food production in fall in wet year types – targeted to Delta smelt but may improve food resources for salmonids in Delta	Beneficial: Low	Small	Medium	Low	Uncertain	Uncertain benefits -

[16] *Water temperature above 53.5°F was the primary stressor created by the proposed action that would impact eggs and fry.*
[17] *Exposure could occur from May through October*

8.6.13.2 CV Spring-Run Chinook salmon

Table 107. Summary of Bay-Delta Division operation related effects on CV spring-run Chinook salmon.

Action Component	Life Stage	Stressor/ Factor	Individual Response and Rationale of Effect	Severity of Stressor/Level of Benefit	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness
Contra Costa Water District Rock Slough water diversions	Juveniles	Passage impediments/Barriers - altered migratory path	Delayed migration and increased transit times due to routing into the channel of Rock Slough where predation is likely to be elevated	Sublethal to Lethal	Small	High	Low	Medium	reduced fitness due to delay in migration or mortality from increased predation
CVP Improvements - predator removal from secondary channel at Tracy Fish Collection Facility	Juveniles	CO2 injections	Removal of predators from secondary channel at the Tracy Fish Collection Facility	Beneficial: High	Medium	High	High	Medium	Increased survival
CVP Improvements - predator removal from secondary channel at Tracy Fish Collection Facility	Juveniles	CO2 Injections	CO2 exposure expected to result in death of fish	Sublethal to Lethal	Small	High	Low	Medium	Mortality of fish exposed

Action Component	Life Stage	Stressor/ Factor	Individual Response and Rationale of Effect	Severity of Stressor/Level of Benefit	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness
CVP/SWP exports	Juveniles	Shift in Operations	Shift in exports to CVP from SWP to reduce impacts of predation from the Clifton Court Forebay when capacity at CVP exists	Beneficial: High	Small	Medium	Medium	Medium	Increased survival
CVP/SWP South Delta Exports	Juveniles	Altered hydrodynamics in south Delta/ routing	Mortality or decreases in condition due to migratory delays in response to altered hydrodynamics in channels of the south Delta. Loss of appropriate migratory cues. Delays increase transit time and exposure to predators, poor water quality, and contaminants.	Sublethal to Lethal	Medium	High	Medium to High	Medium	Reduced survival, reduced growth; likely lesser effect in final proposed action due to revised loss thresholds, though no loss threshold specific to spring-run.

Action Component	**Life Stage**	**Stressor/ Factor**	**Individual Response and Rationale of Effect**	**Severity of Stressor/Level of Benefit**	**Proportion of Population Exposed**	**Frequency of Exposure**	**Magnitude of Effect**	**Weight of Evidence**	**Probable Change in Fitness**
CVP/SWP South Delta Exports	Juveniles	Entrainment and loss at the south Delta export facilities	Loss is approximately 35% at the CVP and 84% at the SWP fish salvage facilities	Sublethal to Lethal	Small	High	Medium to High	High	reduced survival; likely lesser effect in final proposed action due to revised loss thresholds, though no loss threshold specific to spring-run.
DCC Gate operations -	Juveniles	Altered Hydrodynamics downstream of DCC location	Increased mortality when gates are open due to changes in routing or transit time through interactions with changes in river flow and tidal influence downstream of DCC location and gate operations	Minor to Lethal	Medium -	High	High	High	No measurable change to mortality of juveniles exposed

Action Component	Life Stage	Stressor/ Factor	Individual Response and Rationale of Effect	Severity of Stressor/Level of Benefit	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness
DCC Gate operations -	Juveniles	Routing	increased mortality due to routing into the delta interior with lower survival rates	Sublethal to Lethal	Medium -	Low	Medium-High	High	Reduced survival; lesser effect in final proposed action due to revised DCC operations in December-January
DCC Gate operations -	Juveniles	Increased entrainment and loss at the South Delta Exports facilities	Increased mortality of entrained fish at the CVP and SWP fish salvage facilities	Sublethal to Lethal	Small to Medium	High	Low	High	reduced survival; lesser effect in final proposed action due to revised DCC operations in December-January

Action Component	Life Stage	Stressor/ Factor	Individual Response and Rationale of Effect	Severity of Stressor/Level of Benefit	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness
DCC Gate operations -	Juveniles	Transit times	Increased mortality due to increased migration times with concurrent increased exposure to predators	Sublethal to Lethal	Medium -	Low	Medium to High	High	Reduced survival; lesser effect in final proposed action due to revised DCC operations in December-January
North Bay Aqueduct	Juveniles	Entrainment and impingement onto fish screens	Injury or mortality caused by entrainment and/or impingement on the screens at the North Bay Aqueduct, Barker Slough Pumping Plant intake	Sublethal to Lethal	Small	High	Low	High	Reduced fitness or mortality of juveniles exposed
North Bay Aqueduct	Juveniles	Routing	Increased mortality due to routing into the channels of the Lindsey Slough/ Barker Slough region	Sublethal to Lethal	Small	High	Low	Medium	Reduced fitness or mortality of juveniles exposed
North Bay Aqueduct	Juveniles	Impingement/ capture during aquatic weed cleaning	Injury or death due to impingement, capture by grappling hooks during weed removal	Sublethal to Lethal	small	Low	Low	Low	Reduced fitness or mortality of juveniles exposed

Action Component	Life Stage	Stressor/ Factor	Individual Response and Rationale of Effect	Severity of Stressor/Level of Benefit	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness
North Bay Aqueduct	Juveniles	Entrainment during sediment cleaning	Injury or death due to entrainment into dredge or impingement onto fish screens	Sublethal to Lethal	Small	Low	Low	Low	Reduced fitness or mortality of juveniles exposed
Predator removal studies	Juveniles	capture in sampling gear	Increased vulnerability to injury and predation due to entanglement/entrapment in sampling gear	Sublethal to Lethal	Small	Low	Low	Medium	reduced survival
Sacramento Deep Water Ship Channel Food Study	Juveniles	Altered hydrodynamics and migration routing in the Ship Channel	Potential delays and false attraction to the opening and closing of the boat locks, potential diversion from Sacramento River into Deepwater ship channel when boat locks are open, exposure to reduced water quality in Port of Sacramento and Deepwater ship channel, increased exposure to angling and poaching, predation for juvenile fish	Sublethal to Lethal	Low	Low	Low	Low	Reduced fitness

Action Component	Life Stage	Stressor/ Factor	Individual Response and Rationale of Effect	Severity of Stressor/Level of Benefit	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness
Suisun Marsh Roaring River Distribution System Food Subsidy Studies	Juveniles	Temporary change in water flow/water quality (20 days Oct-May, 60 days June-Sept)	During the annual 20 days of periodic operation Oct - May, individual adult spring-run may be delayed in their spawning migration from a few hours to several days. Juveniles may be delayed on their downstream movements by closed gates for several hours while gates are closed on flood tides.	Minor	Low	Low	Low	Medium	not expected to create long-term harm to the fish, or result in injuries leading to mortality
Water Transfers	Juveniles	Transit times	Elevated river flows may reduce transit times through riverine reaches of the Delta	minor	Small	Low	Low	Low	not expected to create long-term harm to the fish, or result in injuries leading to mortality

Action Component	Life Stage	Stressor/ Factor	Individual Response and Rationale of Effect	Severity of Stressor/Level of Benefit	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness
Suisun Marsh Roaring River Distribution System Food Subsidy Studies	Adult Adult migration (Jan – June)	Temporary change in water flow/water quality (20 days Oct-May, 60 days June-Sept)	During the annual 20 days of periodic operation Oct - May, individual adult spring-run may be delayed in their spawning migration from a few hours to several days. Juveniles may be delayed on their downstream movements by closed gates for several hours while gates are closed on flood tides.	Minor	Small	Low	Low	Medium	No measurable change in fitness
DCC Gate operations -	Adult Jan - June	Routing	Increased straying into the Mokelumne River system when gates are opened, followed by migratory delays when gates are closed for water quality concerns	Minor	Small	Medium	Low	Medium	Delayed migration, possible reduction of spawning success; lesser effect in final proposed action due to revised DCC operations in December-January

Action Component	Life Stage	Stressor/ Factor	Individual Response and Rationale of Effect	Severity of Stressor/Level of Benefit	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness
Sacramento Deep Water Ship Channel Food Study	Adult Adult migration (Jan – June)	Altered hydrodynamics and migration routing in the Ship Channel	Potential delays and false attraction to the opening and closing of the boat locks, potential diversion from Sacramento River into Deepwater ship channel when boat locks are open, exposure to reduced water quality in Port of Sacramento and Deepwater ship channel, increased exposure to angling and poaching, predation for juvenile fish	Sublethal to Lethal	Small	Low	Low	Low	Reduced fitness
Predator removal studies	Adult Adult migration - Jan - June	capture in sampling gear	Increased vulnerability to injury and mortality due to entanglement/entrapment in sampling gear	Sublethal to Lethal	Small	Low	Low	Medium	reduced survival

8.6.13.3 CCV Steelhead

Table 108. Summary of proposed action-related effects on juvenile California Central Valley steelhead.

Action Component	Stressor	Individual Response and Rationale of Effect	Severity of Stressor/Level of Benefit	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness
DCC Gate operations	Routing and transit times	increased mortality due to routing into the delta interior with lower survival rates, increased migration times with concurrent increased exposure to predators	sublethal to lethal	medium - gates open from Oct 1 through Nov 30, typically closed Dec 1 through Jan 31. Closed Feb 1 through May 20. Estimated 25% to 50% of juvenile SH population emigrates by the end of January.	low. DCC gates infrequently operated in December and January	High	High - There are a number of publications regarding the relative survival in various North Delta and Central Delta migratory routes; conclusions supported by modeling results. but not steelhead; routing and transit time conclusions supported by modeling results.	Reduced survival; lesser effect in final proposed action due to revised DCC operations in December-January

Action Component	Stressor	Individual Response and Rationale of Effect	Severity of Stressor/Level of Benefit	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness
DCC gate operations	Increased entrainment and loss at the South Delta Exports facilities	Increased mortality of entrained fish at the CVP and SWP fish salvage facilities	Sublethal to lethal	Small to medium	High	Low - sustained population effects on a small to medium proportion of the population present in the Delta	High - numerous studies have evaluated the potential risk to salmonids entering the Delta interior and becoming vulnerable to entrainment at the fish salvage facilities	Reduced survival; lesser effect in final proposed action due to revised DCC operatoins and revised loss thresholds.
CVP Improvements	CO2 injections	Removal of predators from secondary channel at the Tracy Fish Collection Facility	Beneficial: High	medium	high	high	Medium – several studies have looked at predation impacts in the salvage process, long term effectiveness of this method is not certain	Increased survival

Action Component	Stressor	Individual Response and Rationale of Effect	Severity of Stressor/Level of Benefit	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness
CVP/SWP South Delta Exports	Altered hydrodynamics in south Delta/ routing	Mortality or decreases in condition due to migratory delays in response to altered hydrodynamics in channels of the south Delta. Loss of appropriate migratory cues. Delays increase transit time and exposure to predators, poor water quality, and contaminants.	Sublethal to lethal	Medium -	High- continual exports	Medium	Medium to High - effects of hydrodynamics well studied and modeled. Effects of hydrodynamics on salmonid migrations in south Delta less certain.	Reduced survival, reduced growth; likely lesser effect in final proposed action due to revised loss thresholds.
CVP/SWP South Delta Exports	Entrainment and loss at the south Delta export facilities	Loss ranges from approximately 1-8 percent of Delta juvenile fish population at salvage facilities. See 2.8.5.2.5 Population Context below	Sublethal to lethal	small (overall CCV population), medium to large for SJR baisn steelhead)	high	Medium - sustained high frequency exposure on small proportion of population	High - Numerous studies have evaluated the efficiency of the screening facilities, predation, as well as survival through the facilities	reduced survival; lesser effect in final proposed action due to revised loss thresholds.

Action Component	Stressor	Individual Response and Rationale of Effect	Severity of Stressor/Level of Benefit	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness
South Delta Agricultural Barriers	transit times	Delayed migration and increased transit times with potential for increased mortality due to increased exposure to predators	Sublethal to lethal	medium - includes SJR population	high	Medium - installation of barriers occurs during Steelhead migratory period, exposure to the barriers is expected to be low for Sacramento River basin SH, high for SJR basin population SH.	Medium - several studies have indicated that the barriers increase transit time through the south Delta and increase predation risks. Timing of spring-run in the south Delta channels is well documented by salvage records.	Reduced survival
CVP/SWP exports	Shift in Operations	Shift in exports to CVP from SWP to reduce impacts of predation from the CCF when capacity at CVP exists	Beneficial: High	small	medium	medium	Medium - Several studies show lower losses at the CVP for salvaged fish – availability of capacity at the CVP is uncertain	Increased survival

Action Component	Stressor	Individual Response and Rationale of Effect	Severity of Stressor/Level of Benefit	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness
North Bay Aqueduct	Routing	Increased mortality due to routing into the channels of the Lindsey Slough/ Barker Slough region	Minor	small	high	low - very small proportion of population will be present in Barker Slough, low impacts of diversion volumes on hydrodynamics	medium - few salmonids observed in regional monitoring efforts in the past. No fish observed behind screens in monitoring efforts.	reduced survival
North Bay Aqueduct	Entrainment and impingement onto fish screens	Injury and Mortality caused by entrainment and/or impingement on the screens at the North Bay Aqueduct, Barker Slough Pumping Plant intake.	Minor	Small	high - exports occur on annual basis	low - screens are designed for delta smelt criteria, few salmonids expected to be present at screen location	High - monitoring has few observations of salmonids at this location, multiple studies regarding efficiency of positive barrier fish screens	minimal change in fitness
North Bay Aqueduct	Entrainment during sediment cleaning	Injury or death due to entrainment into dredge or impingement onto fish screens	sublethal to lethal	Small	low. Sediment removed infrequently	low - fish unlikely to be in area of screens during cleaning	low. No reports or studies available	minimal change in fitness

Action Component	**Stressor**	**Individual Response and Rationale of Effect**	**Severity of Stressor/Level of Benefit**	**Proportion of Population Exposed**	**Frequency of Exposure**	**Magnitude of Effect**	**Weight of Evidence**	**Probable Change in Fitness**
North Bay Aqueduct	Impingement/ capture during aquatic weed cleaning	Injury or death due to impingement, capture by grappling hooks during weed removal	sublethal to lethal	Small	low. Aquatic weeds removed infrequently	low - fish unlikely to be in area of screens during cleaning	low. No reports or studies available	minimal change in fitness
Contra Costa Water District Rock Slough water diversions	routing	Delayed migration and increased transit times with potential for increased mortality due to routing into the channel of Rock Slough where predation is likely to be elevated	sublethal to lethal	Small	high - pumping through the Rock Slough diversion occurs every year	low - small numbers of fish are likely to be in the vicinity of the fish screens and intake	Medium - annual monitoring reports indicate that no fish are entrained through the screens, however some fish are observed in front of the screens, and have been observed in historical monitoring.	reduced fitness due to delay in migration or increased predation.
Predator removal studies	capture in sampling gear	Increased vulnerability to injury and predation due to entanglement/entrapment in sampling gear	Sublethal to lethal	small (overall CCV population), medium to large for SJR baisn steelhead)	low	Low - infrequent sampling over two to three years of study	Medium - Several reports from previous predator removal studies, literature on sampling methods.	reduced survival

Action Component	Stressor	Individual Response and Rationale of Effect	Severity of Stressor/Level of Benefit	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness
CVP Improvements	CO2 Injections	Small increase in morbidity and mortality due to CO2 exposure during predator clean outs of secondary channel	Sub-lethal to lethal	small	high	low	Medium – several studies show effectiveness of CO2 in removal of predators and sensitivity of smaller fish to CO2 exposure	Reduced fitness
Suisun Marsh Roaring River Distribution System Food Subsidy Studies	Temporary change in water flow/water quality (20 days Oct-May, 60 days June-Sept)	Juveniles may be delayed on their downstream movements by closed gates for several hours while gates are closed on flood tides.	minor	low	Low	low	Low- data on steelhead migration and rearing in Suisun Marsh is low	minimal
Water Transfers	Transit times	Elevated river flows may reduce transit times through riverine reaches of the Delta	Beneficial: low	Small	low	low	low. No reports or studies available	increased fitness

Action Component	Stressor	Individual Response and Rationale of Effect	Severity of Stressor/Level of Benefit	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness
Sacramento Deep Water Ship Channel Food Study	Altered hydrodynamics and migration routing in the Ship Channel	Potential delays and false attraction to the opening and closing of the boat locks, potential diversion from Sacramento River into Deepwater ship channel when boat locks are open, exposure to reduced water quality in Port of Sacramento and Deepwater ship channel, increased exposure to angling and poaching, predation for juvenile fish	Sublethal to Lethal	low	low	low	Low – little information on steelhead migration behavior and use within the Sacramento Deepwater ship channel, and Port of Sacramento	Reduced fitness

Table 109. Summary of proposed action-related effects on adult California Central Valley steelhead.

Action Component	Stressor	Individual Response and Rationale of Effect	Severity of Stressor/Level of Benefit	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness
DCC Gate operations	Routing	Increased straying into the Mokelumne River system when gates are opened, followed by migratory delays when gates are closed. Gate operations for water quality concerns	Minor	High - gates opened over summer and into fall while adults are migrating. Potential for closures Nov - Jan.	High- opened and closed annually	Medium	medium - tagging studies related to straying of Chinook through the DCC when open. Should apply to steelhead	Delayed migration, possible reduction of spawning success; lesser effect in final proposed action due to revised DCC operations in December-January

Action Component	Stressor	Individual Response and Rationale of Effect	Severity of Stressor/Level of Benefit	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness
South Delta Agricultural Barriers	transit times	Delayed migration and increased transit times with potential for increased mortality due to increased exposure to warmer water conditions while moving upriver over barriers	Sublethal to lethal	Low- only SJ River population	high	Medium - installation of barriers occurs during adult SH migratory period, exposure to the barriers is expected to be high for SJR basin population SH.	Medium - several studies have indicated that the barriers increase transit time through the south Delta and increase predation risks. Timing of spring-run in the south Delta channels is well documented by salvage records.	Reduced survival

Action Component	Stressor	Individual Response and Rationale of Effect	Severity of Stressor/Level of Benefit	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness
Predator removal studies	capture in sampling gear	Increased vulnerability to injury and mortality due to entanglement/entrapment in sampling gear	Sublethal to lethal	Small	low	Low - infrequent sampling over two to three years of study	Medium - Several reports from previous predator removal studies, literature on sampling methods.	reduced survival
Suisun Marsh Roaring River Distribution System Food Subsidy Studies	Temporary change in water flow/water quality (20 days Oct-May, 60 days June-Sept)	During the annual 70 to 80 days of periodic operation, individual adult steelhead may be delayed in their spawning migration from a few hours to several days.	minor	low	Low	low	Low- data on steelhead migration and rearing in Suisun Marsh is low	minimal
Water Transfers	low flows	Elevated river flows may reduce straying by providing stronger homing cues to adult steelhead migrants in the lower reaches of the Delta	Beneficial: low	Large	low	low	low. No reports or studies available	increased fitness

Action Component	Stressor	Individual Response and Rationale of Effect	Severity of Stressor/Level of Benefit	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness
Fall Delta Smelt Habitat Operations	Temporary change in water flow/water quality	Potential changes in Delta hydrodynamics due to export reductions and increased Delta inflow from upstream may create better flow attractions for upstream migrations of adult steelhead	Minor benefit	high	Medium (September and October of above normal and wet water year types)	Low – adult steelhead already migrate upstream during this period	Low – little information available on adult migration cues in the Delta	Minimal benefit
Sacramento Deep Water Ship Channel Food Study	Altered hydrodynamics and migration routing in the Ship Channel	Potential delays and false attraction to the opening and closing of the boat locks, potential diversion from Sacramento River into Deepwater ship channel when boat locks are open, exposure to reduced water quality in Port of Sacramento and Deepwater ship channel, increased exposure to angling and poaching	Sublethal to Lethal	low	low	low	Low – little information on steelhead migration behavior and use within the Sacramento Deepwater ship channel, and Port of Sacramento	Reduced fitness

8.6.13.4 sDPS green sturgeon

Below the components of the proposed action in the Bay-Delta Division are summarized by their effects on various life stages of sDPS green sturgeon (Table 110 and Table 111).

Table 110. Summary of Bay-Delta Division operation-related effects on juvenile Southern Distinct Population Segment green sturgeon.

Action Component	Stressor	Individual Response and Rationale of Effect	Severity of Stressor/Level of Benefit	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness
DCC gate operations	Flow conditions	Movement into the Mokelumne River system from the Sacramento River; increased routing distance to the western Delta	Minor	Large	High	Medium	Low	Not expected to create long-term harm to the fish, or result in injuries leading to mortality
DCC gate operations	Flow conditions	When gates are closed, riverine reach of Sacramento extends farther downstream, less tidal influence, faster transit times. When gates are opened, more routing into Delta interior	Minor	Large	High	Medium	Low	Minimal negative change in fitness, potential exposure to lower quality rearing habitat; lesser effect in final PA due to revised operations in December-January.
DCC gate operations	Entrainment	Increased mortality of fish at the fish collection facilities	Sublethal to Lethal	Small to Medium	High	Low	Medium	Reduced survival
Sacramento Deep Water Ship Channel Food Study	Flow conditions	Potential delays and false attraction to the opening and closing of the boat locks, potential diversion from Sacramento River, exposure to reduced water quality, increased exposure to angling and poaching, increased	Sublethal to Lethal	Low	Low	Low	Low	Reduced fitness

Action Component	Stressor	Individual Response and Rationale of Effect	Severity of Stressor/Level of Benefit	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness
		exposure to shipping traffic and ship strikes						
Suisun Marsh Roaring River Distribution System Food Subsidy Studies	Temporary change in water flow/water quality (20 days Oct-May, 60 days June-Sept)	During the annual 70 to 80 days of periodic operation, individual juveniles green sturgeon may be delayed in their downstream migration from a few hours to several days.	Minor	Low	Low	Low	Low	Minimal
North Delta Food Subsidies/ Colusa Basin Drain	Temporary water quality (July/Sept)	During agricultural drainage into the N Delta, juvenile green sturgeon are likely to be exposed to potential increase in contaminants. Potential increase in water temp from ag ditch water (not described in ROC on LTO BA).	Minor	Low	Low	Low	Low	Minimal
Water Transfer Window Extension	Low fall flows	Elevated flows in October or November due to additional water being transferred may decrease transit times to the Delta in riverine reaches	Beneficial: Low	Medium	Medium	Low	Low	Minimal benefit
Fall Delta Smelt Habitat Operations	Temporary change in water flow/water quality	Potential changes in Delta hydrodynamics due to export reductions and increased Delta inflow from upstream may reduce entrainment at the export facilities and create better foraging opportunities, induce downstream migrations	Beneficial: Low	Medium	Medium	Low	Low	Minimal benefit

Action Component	Stressor	Individual Response and Rationale of Effect	Severity of Stressor/Level of Benefit	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness
CVP/SWP South Delta Exports	Altered hydrodynamics in South Delta/ routing	Mortality or decreases in condition due to migratory delays in response to altered hydrodynamics in channels of the South Delta. Loss of appropriate migratory cues. Delays increase transit time and exposure to predators, poor water quality, and contaminants.	Sublethal to Lethal	Medium	High	Medium	Medium	Reduced survival, reduced growth; likely lesser effect in final PA due to revised loss thresholds associated with OMR management.
North Bay Aqueduct	Entrainment and impingement onto fish screens	Injury and Mortality caused by entrainment and/or impingement on the screens at the North Bay Aqueduct, Barker Slough Pumping Plant intake.	Minor	Small	High	Low	High	Minimal negative change in fitness
North Bay Aqueduct	Routing	Increased migration times to western Delta	Minor	Small	High	Low	Low	Minimal negative change in fitness
CCF aquatic weed control	Exposure to herbicides	Adverse physiological effects (i.e., reduced growth and survival), and increased vulnerability to predation due to exposure to harmful compounds in the water	Sublethal to Lethal	Small	High	Medium	Medium	Reduced survival
South Delta Agricultural Barriers	Transit times	Delayed migration and increased transit times with potential for increased mortality due to increased exposure to poor water quality and high water temperatures	Sublethal to Lethal	Small	High	Medium	Medium	Reduced survival
CVP/SWP South Delta Exports	Entrainment and loss at the South	Entrainment of juvenile green sturgeon into the fish salvage facilities, unknown	Sublethal to Lethal	Small	High	Medium	High	Reduced survival; lesser effect in final PA due to revised

Action Component	Stressor	Individual Response and Rationale of Effect	Severity of Stressor/Level of Benefit	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness
	Delta export facilities	vulnerability to predation or loss through louvers. Largest estimated entrainment increases under PA are during wet years: 4.4% to 9.3%						loss thresholds associated with OMR management.
CCWD Rock Slough water diversions	Routing	Delayed migration and increased transit times	Minor	Small	High	Low	Low	Minimal change in fitness
Predator removal studies	Capture in sampling gear	Increased vulnerability to injury and predation due to entanglement/ entrapment in sampling gear	Sublethal to Lethal	Small	Low	Low	Medium	Reduced survival, potential injury from gear or handling
North Bay Aqueduct	Impingement/ capture during aquatic weed cleaning	Injury or death due to impingement, capture by grappling hooks during weed removal	Sublethal to Lethal	Small	Low	Low	Low	Minimal change in fitness
North Bay Aqueduct	Entrainment during sediment cleaning	Injury or death due to entrainment into dredge or impingement onto fish screens	Sublethal to Lethal	Small	Low	Low	Low	Minimal change in fitness

Table 111. Summary of Bay-Delta Division operation-related effects on adult Southern Distinct Population Segment green sturgeon.

Action Component	Stressor	Individual Response and Rationale of Effect	Severity of Stressor/Level of Benefit	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness
DCC Gate operations	Routing	Movement into and through the Mokelumne River system, increased transit distance to/from western Delta	Minor	Large	High	Medium	Low	Delayed migration, possible reduction of

Action Component	**Stressor**	**Individual Response and Rationale of Effect**	**Severity of Stressor/Level of Benefit**	**Proportion of Population Exposed**	**Frequency of Exposure**	**Magnitude of Effect**	**Weight of Evidence**	**Probable Change in Fitness**
								spawning success
Sacramento Deep Water Ship Channel Food Study	Altered hydrodynamics and migration routing in the Ship Channel	Potential delays and false attraction to the opening and closing of the boat locks, potential diversion from Sacramento River, exposure to reduced water quality, increased exposure to angling and poaching, increased exposure to shipping traffic and ship strikes	Sublethal to Lethal	Low	Low	Low	Low	Reduced fitness
Suisun Marsh Roaring River Distribution System Food Subsidy Studies	Flow Conditions, Water quality	individual green sturgeon may be delayed in their spawning migration from a few hours to several days	Minor	Low	Low	Low	Low	Minimal
North Delta Food Subsidies/ Colusa Basin Drain	Temporary water quality (July/Sept)	May be temporarily exposed to increased contaminants from agricultural drainage from Colusa Basin Drain to Cache Slough during July and September.	Minor	Low	Low	Low	Low	Minimal
Water Transfer Window Extension	Flow conditions	Elevated flows in October or November due to additional water being transferred may decrease transit times to the Delta in riverine reaches	Beneficial: Low	Medium	Medium	Low	Low	Minimal benefit
Fall Delta Smelt Habitat Operations	Flow conditions Entrainment	Potential changes in Delta hydrodynamics due to export reductions and increased Delta inflow from upstream may reduce entrainment at the export facilities and create better foraging opportunities, induce downstream migrations	Beneficial: Low	Medium	Medium	Low	Low	Minimal benefit

Action Component	Stressor	Individual Response and Rationale of Effect	Severity of Stressor/Level of Benefit	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness
Clifton Court Forebay aquatic weed control	Exposure to herbicides	Adverse physiological effects (i.e., reduced growth and survival), due to exposure to harmful compounds in the water	Sublethal to Lethal	Small	High	Medium	Medium	Reduced survival
South Delta Agricultural Barriers	Transit times	Delayed migration and increased transit times with potential for increased mortality due to increased exposure to poor water quality and high water temperatures	Sublethal to Lethal	Small	High	Medium	Medium	Reduced survival

8.7 East Side Division

8.7.1 Stanislaus River

The main components of the proposed action for the Stanislaus River covered in this effects analysis fall into the categories of: water temperature management and flow management. Both water temperature management and flow management include several sub-categories. This analysis focuses on key elements of Reclamation's operation of New Melones Dam, and related dams of the East Side Division (Figure 123).

NMFS deconstructed the proposed action to identify the project components (Figure 124) that would create stressors that may affect listed species (Table 112). The exposure, risk, and response of CCV steelhead to the project-related stressors are then analyzed in the following sections for each proposed action component.

Figure 123. Area map of key locations in the East Side Division.

Source: Modified from Figure 1-7 of ROC on LTO biological assessment

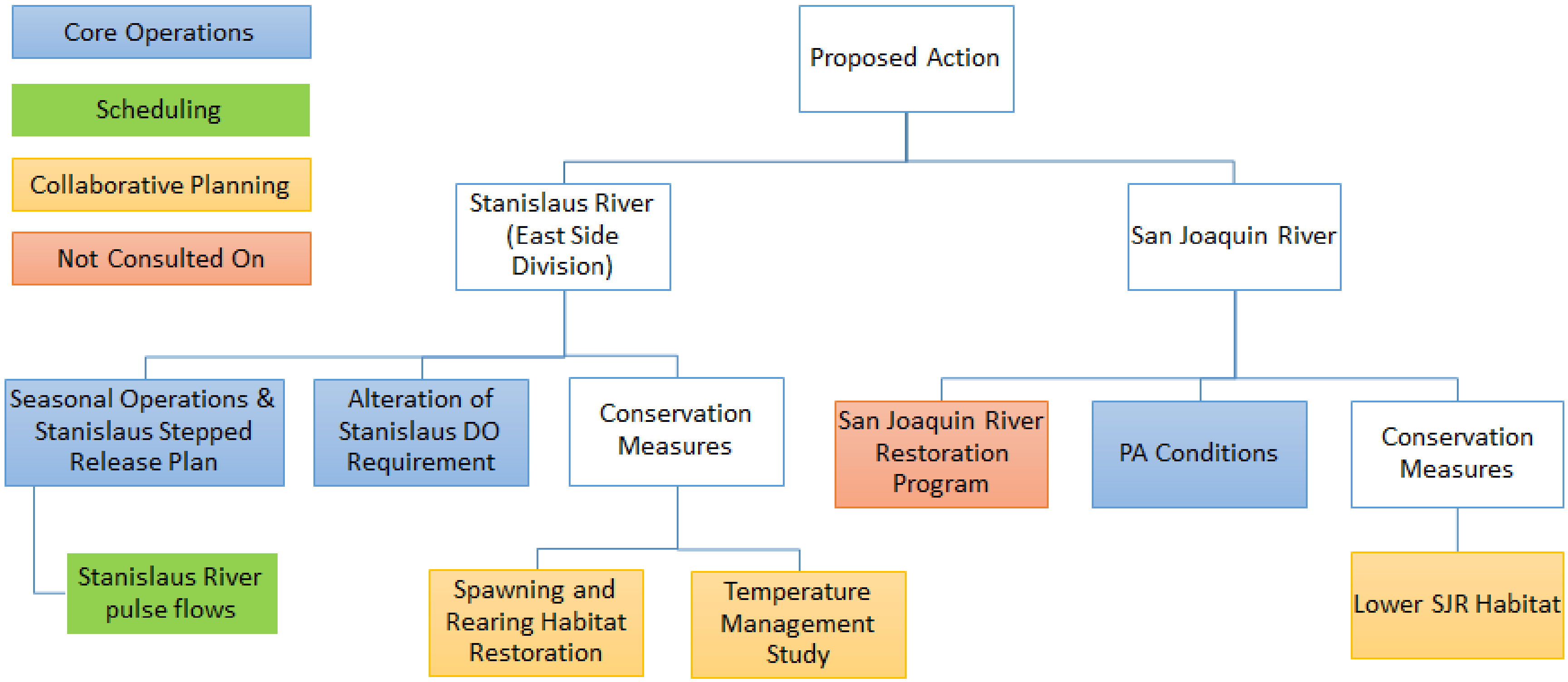


Figure 124. Deconstructed project components in the Stanislaus and San Joaquin rivers (East Side Division).

Due to a continued high demand for limited water supply in the Central Valley, numerous stressors continue to affect the viability of salmonid populations. Table 112 provides a summary of which stressors from 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) were analyzed under each proposed action component within this effects analysis for the Stanislaus River (East Side Division).

Table 112. Stressors created by components of the proposed action in the Stanislaus River.

Project Component	Passage Impediments/ Barriers	Water Temperature	Water Quality	Water flow
Seasonal Operations and Stanislaus Stepped Release Plan	X	X	-	X
Alteration of Stanislaus dissolved oxygen requirement	-	-	X	-
Conservation Measures – Spawning and Rearing Habitat Restoration	-	-	-	-
Conservation Measures – Temperature Management Study	-	X	-	X

An "X" indicates that the action component affects a stressor category; the response could be negative or positive.

8.7.1.1 Seasonal Operations and Stanislaus Stepped Release Plan

Releases at Goodwin Dam to the Stanislaus River under the current operating scenario (current modeling representation of project operations at the time of consultation) or proposed action may exceed the proposed minimum fishery flows in Appendix 2-E (for current operating scenario) or the stepped release plan (for proposed action) for a variety of reasons, including flood control, reservoir storage management, and other regulatory requirements. Some key uncertainties in the proposed action for the East Side Division relate to Reclamation's assumptions about changes to regulatory requirements or agreements that are in flux or may not be fully within Reclamation's discretion to change. The assumptions in question include:

> Vernalis flows in D-1641: Modeling for the current operating scenario scenario assumes only the February through June "base flow" requirements at Vernalis (which might result in releases into the Stanislaus River above Appendix 2-E flows), and does not include the October and spring pulse flows at Vernalis in D-1641[18]. Modeling for the proposed action

[18] Reclamation's perspective on the Vernalis flow requirements is provided in an April 12, 2018, letter from Reclamation to the SWRCB, available from the California Water Boards Sacramento-San Joaquin Bay-Delta Estuary Decision 1641 Compliance page.

scenario does not assume any Vernalis flow standard at any time of the year[19]; Vernalis flows are simply the results of upstream contributions, including the stepped release plan.

Because of the State Water Resource Control Board's efforts to update the Bay Delta Water Quality Control Plan, there is uncertainty about what Vernalis flow requirements will be in January 2020. NMFS analyzed the effects as modeled.

Vernalis Electrical Conductivity in D-1641: Modeling for the current operating scenario assumes the Vernalis electrical conductivity standards in D-1641 (which might result in releases into the Stanislaus River above Appendix 2-E flows). Modeling for the proposed action scenario does not assume any Vernalis electrical conductivity standard[20]; Vernalis electrical conductivity is simply the result of upstream contributions, including the stepped release plan.

Because of the State Water Resource Control Board's efforts to update the Bay Delta Water Quality Control Plan, there is uncertainty about what Vernalis electrical conductivity requirements will be in January 2020. NMFS analyzed the effects as modeled.

Ripon Dissolved Oxygen standard in D-1422: One component of the proposed action is to shift the compliance location for the dissolved oxygen standard (in D-1422) about 30 river miles upstream (from Ripon to Orange Blossom Bridge) during the summer. Modeling for the current operating scenario and proposed action do not differ (though the narrative acknowledges that flows might occasionally be lower during the summer due to this component of the proposed action). Neither NMFS nor Reclamation has the authority to approve a shift in this dissolved oxygen compliance location, so NMFS assumes that Reclamation will obtain any necessary approvals for this change before implementation of this proposed action component. The range of effects prior to implementation of the shift in dissolved oxygen compliance location is within the range of effects evaluated assuming the compliance location is changed, so coverage is provided both before and after the necessary approvals are obtained.

"1987 Agreement[21]" between Reclamation and (then) California Department of Fish and Game: Modeling assumptions include the "1987 Agreement" as a factor in the current operating scenario scenario (though the modeling assumes that the Appendix 2-E flows from the NMFS 2009 Opinion satisfy the "1987 Agreement"). The proposed action scenario assumes that the stepped release plan supersedes the "1987 Agreement." NMFS

[19] In a consultation meeting on May 24, 2019, Reclamation clarified that some Vernalis flow standard may be in place by January 2020, but that the CVP contribution would be considered met by Stanislaus operations under the proposed action.

[20] In a consultation meeting on May 24, 2019, Reclamation clarified that some Vernalis EC standard may be in place by January 2020, but that the CVP contribution would be considered met by Stanislaus operations under the proposed action.

[21] The 1987 Agreement is an agreement between California Department of Fish and Game and the United States Department of the Interior Bureau of Reclamation regarding interim instream flows and fishery studies in the Stanislaus River below New Melones Reservoir.

analyzed the effects as modeled and defers to Reclamation and the California Department of Fish and Wildlife to resolve the issue.

8.7.1.2 Review of Stanislaus River Flows under the proposed action

Dam operations typically alter the downstream hydrograph from the unimpaired hydrograph, and this is true of the CVP's New Melones Dam, most notably by the reduction in annual peak flows due to capture of winter and snowmelt flood flows. Schneider et al. (2000) summarized the flattening of the hydrograph in both wet and dry years after construction of New Melones Dam. In wet year conditions, annual peak flows of 25,000 cfs to 30,000 cfs were reduced to <5,000 cfs. In dry year conditions, annual peak flows of 7,000 cfs to 8,000 cfs were reduced to <1,500 cfs (Figure 125).

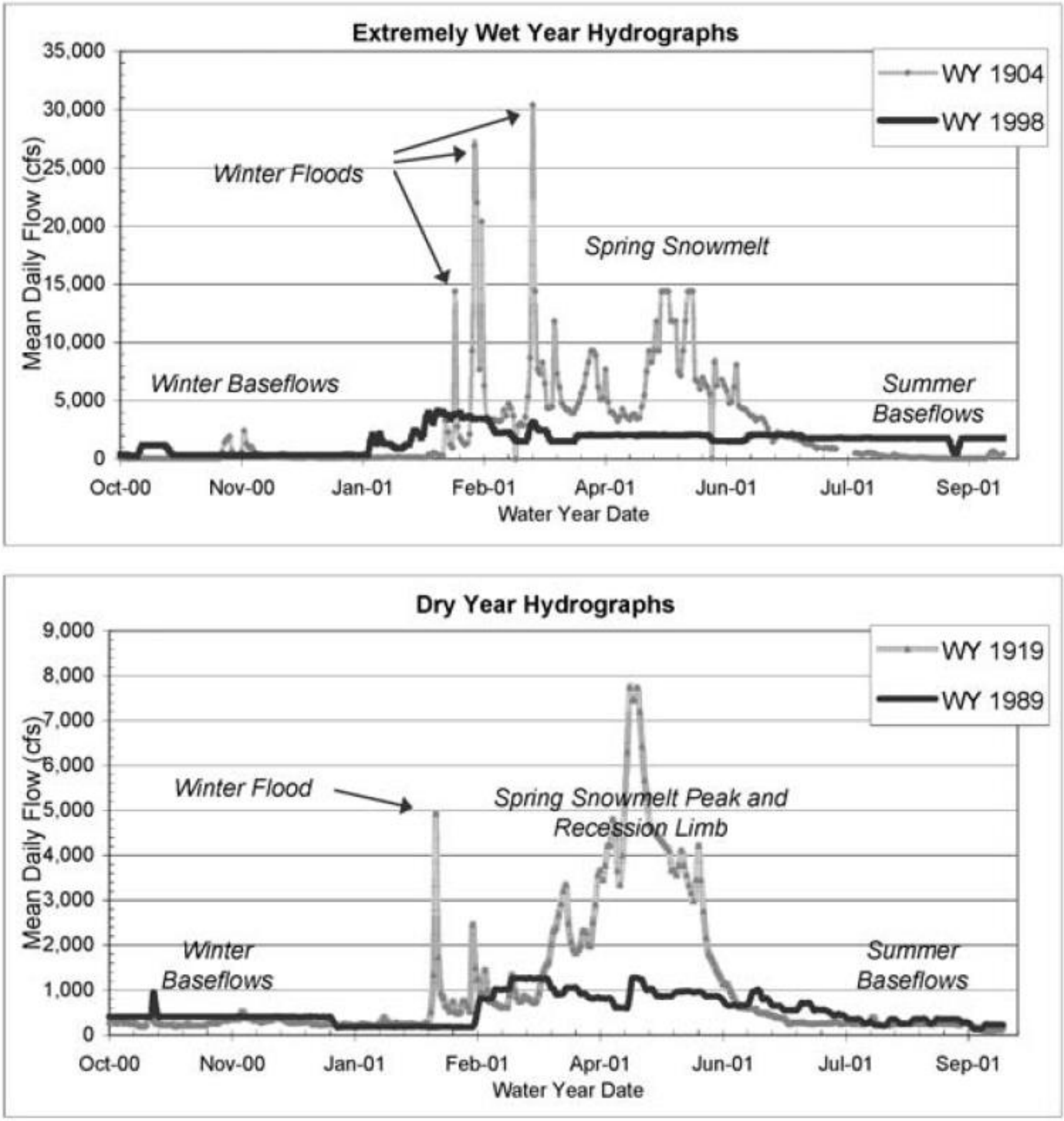


Figure 125. Annual comparison of wet and dry year hydrographs before (1904 and 1919) and after (1989 and 1998) construction of New Melones Dam.

Source: Figure 4 in Schneider et al. (2000)

Further discussion of changes to the flow regime of the Stanislaus River after construction of New Melones Dam is provided in Kondolf et al. (2001). While the hydrologic summary in Figure 125 does not include post-New Melones Dam operations under the NMFS 2009 Opinion, both current and proposed operations on the Stanislaus River show similar hydrologic characteristics, i.e. a flattened hydrograph with limited winter and springtime flows. While the average monthly flow output from CalSimII does not capture peak daily flow, model outputs for the proposed action scenario and current operating scenario scenario show that average monthly flows exceed 2,000 cfs only in March of Wet water year types and never exceed 750 cfs in Critical water years (Figure 125). The daily flow schedules in the stepped release plan (Appendix F) include annual peak flows of 725 cfs (Critical), 1,000 cfs (Dry), 2,000 (Below Normal and Above Normal), and 3,000 cfs (Wet).

Table 113. Exceedance table of average modeled monthly flow in the Stanislaus River below Goodwin Dam for the proposed action scenario and current operating scenario scenario.

	Monthly Flow (Cubic Feet per Second)											
Statistic	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Probability of Exceedance												
10%	837	290	306	358	897	1,648	1,633	1,929	1,100	429	392	390
20%	797	200	218	232	405	1,521	1,553	1,555	1,089	318	300	300
30%	774	200	200	232	282	440	1,553	1,294	940	300	283	250
40%	774	200	200	226	236	200	1,400	1,242	853	300	283	250
50%	774	200	200	226	236	200	1,400	1,242	363	275	283	250
60%	636	200	200	219	229	200	812	918	363	265	283	249
70%	636	200	200	219	229	200	767	705	294	265	283	249
80%	578	200	200	214	221	200	767	631	262	265	283	249
90%	577	200	200	213	215	200	504	547	255	265	283	249
Long Term												
Full Simulation Period[a]	723	278	367	519	593	754	1,159	1,124	680	395	362	351
Water Year Types[b,c]												
Wet (23%)	859	532	863	999	1,193	2,014	1,536	1,691	1,140	716	639	692
Above Normal (24%)	728	205	212	664	676	645	1,224	1,146	959	353	292	267
Below Normal (10%)	752	200	202	282	346	365	1,454	1,201	475	269	285	256
Dry (16%)	677	200	200	234	313	200	1,030	930	375	276	277	245
Critical (27%)	614	200	236	227	255	234	742	700	282	272	264	231

Statistic	Monthly Flow (Cubic Feet per Second) Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep

Proposed Action 011519

Statistic	Monthly Flow (Cubic Feet per Second)											
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Probability of Exceedance												
10%	797	200	306	552	2,259	1,528	1,572	1,555	940	300	300	300
20%	797	200	200	232	294	1,521	1,553	1,555	940	300	300	300
30%	774	200	200	230	236	675	1,553	1,242	363	265	283	250
40%	774	200	200	226	229	200	1,400	1,242	363	265	283	250
50%	774	200	200	226	229	200	1,400	1,242	363	265	283	250
60%	636	200	200	226	229	200	972	819	255	265	283	249
70%	636	200	200	219	221	200	767	631	255	265	283	249
80%	577	200	200	213	214	200	466	400	200	200	200	200
90%	577	200	200	213	214	200	460	400	200	200	200	200
Long Term												
Full Simulation Period[a]	718	272	341	549	722	762	1,147	1,036	566	378	338	339
Water Year Types[b,c]												
Wet (23%)	854	508	735	1,003	1,750	2,189	1,475	1,665	1,499	834	625	691
Above Normal (24%)	774	202	223	694	695	577	1,571	1,255	363	265	283	258
Below Normal (10%)	774	200	202	546	528	247	1,610	1,242	363	265	283	250

Statistic	Monthly Flow (Cubic Feet per Second)											
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Dry (16%)	626	200	209	224	228	200	825	655	256	255	270	241
Critical (27%)	578	200	236	220	222	218	501	445	200	200	200	198

Proposed Action 011519 minus Current Operations 011319

Statistic	Monthly Flow (Cubic Feet per Second)											
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Probability of Exceedance												
10%	**-41**	**-90**	0	194	1,362	**-121**	**-62**	**-375**	**-160**	**-129**	**-92**	**-90**
20%	0	0	**-18**	0	**-111**	0	0	0	**-149**	**-18**	0	0
30%	0	0	0	**-2**	**-46**	236	0	**-52**	**-577**	**-35**	**0**	0
40%	0	0	0	0	**-7**	0	0	0	**-490**	**-35**	0	0
50%	0	0	0	0	**-7**	0	0	0	0	**-10**	0	0
60%	0	0	0	6	0	0	160	**-99**	**-108**	0	0	0
70%	0	0	0	0	**-7**	0	0	**-75**	**-38**	0	0	0
80%	**-1**	0	0	**-1**	**-7**	0	**-300**	**-231**	**-62**	**-65**	**-83**	**-49**
90%	0	0	0	0	**-1**	0	**-44**	**-147**	**-55**	**-65**	**-83**	**-49**
Long Term												
Full Simulation Period[a]	**-4**	**-6**	**-26**	31	129	8	**-11**	**-87**	**-114**	**-17**	**-24**	**-13**
Water Year Types[b,c]												
Wet (23%)	**-5**	**-24**	**-128**	4	557	175	**-61**	**-26**	359	118	**-14**	**-1**

	Monthly Flow (Cubic Feet per Second)											
Statistic	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Above Normal (24%)	46	**-3**	11	31	20	**-68**	347	109	**-596**	**-88**	**-9**	**-9**
Below Normal (10%)	22	0	0	264	183	**-118**	156	41	**-111**	**-4**	**-2**	**-6**
Dry (16%)	**-51**	0	9	**-10**	**-86**	0	**-205**	**-274**	**-119**	**-21**	**-6**	**-4**
Critical (27%)	**-36**	0	0	**-7**	**-33**	**-15**	**-241**	**-255**	**-82**	**-72**	**-64**	**-33**

a Based on the 82-year simulation period.
b As defined by the San Joaquin Valley 60-20-20 Index Water Year Hydrologic Classification (State Water Resources Control Board 1999).
c These results are displayed with calendar year - year type sorting.
d All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.
e These are draft results meant for qualitative analysis and are subject to revision.
f New Melones forecasts are used as the basis of water operations.
Source: ROC on LTO biological assessment: Table 37-3 from Appendix D, Attachment 3-2

8.7.1.3 Analysis of Proposed Changes in Operations and Year Type Method under the proposed action

To understand the effects of the proposed changes in operations (due to the stepped release plan and assumptions about other regulatory requirements) and changes in year type method, NMFS assessed the year type distributions for the year type method and operations combinations in Table 114.

Table 114. Comparison of year type method and operations combinations.

Name of scenario	Operations scenario	Year type method	Comments
current operating scenario-New Melones index	Current Operations (with Appendix 2-E flow schedules)	New Melones Index *(for operations and year type assignment in modeling)*	Current Operations Scenario
PA-60-20-20	Proposed Action (with Stepped Release Plan flow schedules)	San Joaquin 60-20-20 Index *(for operations and year type assignment in modeling)*	Proposed Action Scenario

Table 115 describes how the distribution of year types changes under different year type-method and operations combinations. There are more Critical, Above Normal, and Wet water year types and fewer Dry and Below Normal water year types in the proposed action scenario (PA-60-20-20) compared to the current operating scenario scenario (current operating scenario-New Melones index).

Table 115. Distribution of year types under different year type method and operations combinations.

Tier	Year Type	Panel A		Panel B	
		COS-NMI	PA-60-20-20	COS-NMI	PA-60-20-20
4	Critical	18	24	22	29
4	Dry	20	10	24	12
3	Below Normal	21	9	26	11
2	Above Normal	14	20	17	24
1	Wet	9	19	11	23
	Total	82	82	100	100

Because hydrology is the same; a change in proposed action-60-20-20 compared to current operating scenario-New Melones index is likely to be caused by a combined change in the year type method and storage condition due to differing operations under the proposed action.

Table 116 describes results of the comparison between the proposed action and current operating scenario in terms of "year type differential."

Table 116. Comparisons between proposed action and current operating scenario in terms of "year type differential."

Water Year Type Differential	PA-60-20-20 minus COS-NMI	
	Count	Percentage
-3	4	5%
-2	6	7%
-1	18	22%
0	38	46%
1	14	17%
2	2	2%
3	0	0%
Total	82	100%
Minimum	-3	2%
Maximum	2	46%

Critical, Dry, Below Normal, Above Normal, and Wet water year types are represented as 5, 4, 3, 2, and 1, respectively. For example, a year with a proposed action-60-20-20 year type of Above Normal (3), and a current operating scenario-New Melones index year type of Dry (4) would result in a "year type differential" of 3 - 4 = -1.

General conclusions based on Table 116 include:

<u>PA-60-20-20 to current operating scenario-New Melones index</u>

- Comparing proposed action-60-20-20 to current operating scenario-New Melones index controls only for hydrology and thus represents the effect of the COMBINED change in the year type method and storage condition due to differing operations under the proposed action.

- The combined effect is asymmetric, with 28 of 82 years (34 percent) being classified as wetter year types (which might trigger a higher flow schedule per the stepped release plan) and 16 of 82 years (20 percent) being classified as drier water year types (which might trigger a lower flow schedule per the stepped release plan).
- Because the stepped release plan "downshifts" the two highest flow schedules in the NMFS 2009 Opinion's Appendix 2-E (i.e., proposed action's Wet water year type flow schedule is the same as the NMFS 2009 Opinion's Above Normal water year type flow schedule and proposed action's Above Normal water year type flow schedule is the same as the NMFS 2009 Opinion's Below Normal water year type flow schedule), a shift from Below Normal in current operating scenario to Above Normal in the proposed action (or from Above Normal in current operating scenario to Wet in the proposed action) doesn't actually trigger a flow schedule with higher releases.

The proposed action's required minimum flows are lower in Above Normal and Wet water year types (based on stepped release plan tables), so would be lower overall even if year type distribution was unchanged. The current operating scenario and proposed action's modeled flows, however, are more similar than might be expected based on this year type analysis and the required fishery minimum flow schedules (Appendix 2-E in the current operating scenario; stepped release plan in the proposed action). The largest changes are that April and May flows during Dry and Critical water year types are about 200-250 cfs lower in the proposed action compared to the current operating scenario (probably due to the assumption that no Vernalis flow requirement is in effect in the proposed action, compared to an assumption of base Vernalis flows February through June in the current operating scenario). June flows are also lower in the proposed action except in Wet water year types. The greatest reduction in June flows in seen in Above Normal water year types; this is likely the signal from the stepped release plan's implementation of the Appendix 2-E Below Normal flows in an Above Normal water year type. NMFS's interpretation of why larger changes are not observed in the proposed action flows compared to the current operating scenario flows is that in many Above Normal and Wet water year types (the years in which required flows in the proposed action are, in some months, lower than required flows in the current operating scenario), New Melones flood operations occur more often during February, March, and June in the proposed action, and thus modeled flows reflect releases higher than minimum flows, particularly during Wet water year types. Another reason is that the assumptions in the current operating scenario include only base Vernalis flows February to June, and not any of pulse flow elements in D-1641 (in October or mid-April to mid-May), so the proposed action assumption of no Vernalis flow requirements represents less of an operational change than if the current operating scenario assumed the D-1641 Vernalis pulse flow requirements.

8.7.1.4 Review of Stanislaus River Temperatures under the proposed action

Modeled water temperatures show much cooler conditions in Goodwin Canyon below Goodwin Dam (river mile 59) than at Orange Blossom Bridge, (Table 117) about 11 river miles downstream of Goodwin Dam at river mile 47. There is little difference in temperatures between the proposed action and current operating scenario at Goodwin Dam; water temperatures there are largely driven by the temperature of water released from New Melones Dam and any warming in Tulloch Reservoir and Goodwin Reservoir (with residence time not generally expected to change between the current operating scenario and proposed action scenarios). Air temperatures will warm or cool water between Goodwin Dam and Orange Blossom Bridge, and this warming or cooling is buffered at higher flows due to increased thermal mass. Results show that temperatures at Orange Blossom Bridge are often slightly warmer in the proposed action, particularly in June and July. Interpretation of year type differences from these tables is complicated by the fact that both proposed action and current operating scenario flows are summarized by the 60-20-20 year type, even though current operating scenario flows are modeled based on the New Melones index year type.

Table 117. Exceedance table of average modeled monthly average temperature in the Stanislaus River below Goodwin Dam for the proposed action scenario and current operating scenario.

	Monthly Temperature (DEG-F)											
Statistic	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Probability of Exceedance												
10%	60.7	59.2	54.6	51.1	50.8	51.9	53.1	54.1	55.6	57.6	58.3	60.1
20%	58.0	56.5	53.3	50.3	50.2	51.4	52.4	53.6	54.8	55.9	56.5	57.4
30%	56.1	55.5	52.5	49.7	49.5	50.8	52.1	53.0	54.0	55.2	55.8	56.4
40%	55.5	54.8	51.9	49.3	48.9	50.6	51.7	52.8	53.7	54.6	55.2	55.7
50%	55.0	54.2	51.6	48.9	48.8	50.3	51.4	52.6	53.3	54.4	54.8	55.3
60%	54.5	54.0	51.2	48.4	48.4	50.0	51.0	52.1	52.7	53.5	54.2	54.6
70%	54.0	53.5	51.0	48.0	47.9	49.8	50.6	51.8	52.5	53.2	53.9	54.2
80%	53.5	52.9	50.4	47.3	47.4	49.0	50.1	51.5	52.0	52.6	53.3	53.7
90%	52.4	52.1	49.8	46.4	46.7	48.3	49.2	50.6	50.8	51.5	52.2	52.5
Long Term												
Full Simulation Period[a]	56.0	54.9	51.8	48.7	48.7	50.2	51.3	52.5	53.5	54.6	55.3	56.1
Water Year Types[b,c]												
Wet (23%)	52.9	52.4	50.6	47.9	47.7	49.2	50.0	51.3	51.6	52.2	52.8	53.0
Above Normal (24%)	55.2	54.5	51.7	48.4	48.0	49.6	50.6	51.9	52.5	53.5	54.5	55.2
Below Normal (10%)	54.9	54.2	51.5	48.4	48.7	50.0	51.3	52.1	52.9	54.1	54.7	55.1
Dry (16%)	56.7	55.6	52.2	49.2	49.2	50.9	51.9	52.8	53.9	55.1	56.0	56.7
Critical (27%)	59.4	57.3	52.9	49.7	49.9	51.5	52.7	54.3	56.0	57.5	58.2	59.5

	Monthly Temperature (DEG-F)											
Statistic	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**

Proposed Action 011519

	Monthly Temperature (DEG-F)											
Statistic	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Probability of Exceedance												
10%	58.8	57.1	53.7	50.7	50.6	52.0	53.0	54.3	55.6	57.0	57.5	58.1
20%	56.4	55.7	53.1	50.2	50.1	51.4	52.5	53.5	54.8	55.7	56.3	56.7
30%	55.6	54.7	52.5	49.5	49.4	50.9	52.1	53.1	54.1	55.1	55.5	56.1
40%	55.0	54.3	51.8	49.1	49.1	50.6	51.8	52.9	53.7	54.7	55.0	55.3
50%	54.7	53.9	51.4	48.9	48.8	50.3	51.4	52.6	53.2	54.2	54.7	55.0
60%	54.3	53.7	51.2	48.4	48.4	50.0	51.2	52.2	52.7	53.7	54.3	54.6
70%	53.9	53.3	50.8	48.0	47.9	49.8	50.8	52.0	52.4	53.3	53.8	54.2
80%	53.4	52.8	50.3	47.4	47.5	49.0	50.1	51.5	51.9	53.0	53.3	53.7
90%	52.3	52.2	49.5	46.9	47.0	48.5	49.4	50.8	51.1	51.8	52.5	52.5
Long Term												
Full Simulation Period[a]	55.3	54.4	51.7	48.7	48.8	50.3	51.3	52.5	53.4	54.4	55.2	55.6
Water Year Types[b,c]												
Wet (23%)	53.0	52.6	50.7	47.9	47.9	49.1	50.0	51.4	51.7	52.4	53.0	53.2
Above Normal (24%)	55.4	54.3	51.6	48.5	48.2	49.7	50.6	51.9	52.5	53.8	54.7	55.5
Below Normal (10%)	54.4	53.8	51.3	48.5	48.7	50.1	51.6	52.2	52.9	54.0	54.5	54.7

Statistic	Monthly Temperature (DEG-F)											
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Dry (16%)	55.6	54.7	51.9	49.0	49.1	50.9	51.9	52.8	53.9	54.8	55.3	55.8
Critical (27%)	57.4	56.3	52.7	49.6	49.8	51.6	52.7	54.0	55.6	56.7	57.8	58.1

Proposed Action 011519 minus Current Operations 011319

Statistic	Monthly Temperature (DEG-F)											
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Probability of Exceedance[a]												
10%	-1.9	-2.0	-0.9	-0.4	-0.2	**0.1**	-0.1	**0.2**	**0.0**	-0.6	-0.8	-2.0
20%	-1.6	-0.8	-0.2	0.0	-0.1	**0.0**	**0.1**	-0.1	-0.1	-0.1	-0.2	-0.7
30%	-0.5	-0.8	**0.0**	-0.1	-0.1	**0.1**	0.0	**0.0**	**0.1**	0.0	-0.3	-0.3
40%	-0.5	-0.4	-0.1	-0.2	**0.1**	**0.0**	**0.1**	**0.1**	**0.1**	**0.0**	-0.3	-0.4
50%	-0.3	-0.3	-0.1	**0.1**	-0.1	**0.0**	**0.0**	**0.0**	-0.1	-0.2	-0.1	-0.3
60%	-0.2	-0.3	-0.1	**0.0**	0.0	0.0	**0.2**	**0.2**	0.0	**0.2**	**0.0**	0.0
70%	-0.1	-0.1	-0.2	**0.0**	-0.1	**0.0**	**0.2**	**0.1**	-0.1	**0.1**	0.0	0.0
80%	-0.1	-0.1	0.0	**0.1**	**0.1**	-0.1	-0.1	0.0	-0.1	**0.4**	-0.1	0.0
90%	-0.1	**0.1**	-0.2	**0.4**	**0.4**	**0.2**	**0.2**	**0.2**	**0.3**	**0.3**	**0.3**	0.0
Long Term												
Full Simulation Period[a]	-0.7	-0.5	-0.2	0.0	**0.1**	**0.0**	**0.0**	0.0	-0.1	-0.1	-0.1	-0.4
Water Year Types[b,c]												
Wet (23%)	**0.2**	**0.2**	**0.1**	0.0	**0.2**	-0.1	**0.0**	**0.1**	**0.1**	**0.1**	**0.1**	**0.2**

	Monthly Temperature (DEG-F)											
Statistic	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Above Normal (24%)	**0.2**	-0.2	-0.1	**0.1**	**0.2**	**0.1**	**0.0**	**0.1**	0.0	**0.4**	**0.3**	**0.3**
Below Normal (10%)	-0.4	-0.4	-0.2	**0.0**	0.0	**0.1**	**0.3**	**0.1**	**0.0**	-0.1	-0.2	-0.4
Dry (16%)	-1.1	-0.9	-0.3	-0.2	-0.1	**0.0**	0.0	**0.0**	0.0	-0.3	-0.7	-0.9
Critical (27%)	-2.0	-1.0	-0.3	-0.1	0.0	**0.1**	0.0	-0.3	-0.5	-0.7	-0.4	-1.4

a Based on the 82-year simulation period.
b As defined by the San Joaquin Valley 60-20-20 Index Water Year Hydrologic Classification (State Water Resources Control Board 1999)
c These results are displayed with calendar year - year type sorting.
d All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.
e These are draft results meant for qualitative analysis and are subject to revision.
f New Melones forecasts are used as the basis of water operations.

Source: ROC on LTO biological assessment: Table 22-3 from Appendix D, Attachment 3-2

Table 118. Exceedance table of average modeled monthly average temperature in the Stanislaus River at Orange Blossom Bridge for the proposed action scenario and current operating scenario scenario.

Current Operations 011319

	Monthly Temperature (DEG-F)											
Statistic	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Probability of Exceedance												
10%	61.6	58.7	53.4	51.3	52.5	55.8	55.2	57.7	63.7	65.5	65.4	64.5
20%	59.3	56.9	52.6	50.8	51.7	55.1	54.8	56.8	62.4	64.6	64.2	63.3
30%	57.5	56.2	52.2	50.1	51.2	54.6	54.1	55.9	61.6	64.1	63.4	62.0
40%	56.8	55.0	51.5	49.6	50.7	54.0	53.7	55.3	60.6	63.7	62.9	61.7
50%	56.4	54.9	51.0	49.1	50.4	53.8	53.1	55.0	59.3	63.2	62.5	61.2
60%	55.8	54.5	50.7	48.8	50.1	53.2	52.7	54.4	56.6	62.6	62.2	60.7
70%	55.2	54.1	50.5	48.3	49.6	52.1	52.2	53.9	55.9	62.1	61.9	60.4
80%	54.9	53.7	50.1	47.9	49.2	51.0	51.9	53.6	55.3	61.5	61.5	59.9
90%	54.0	52.7	49.7	47.1	48.4	49.6	50.8	52.6	54.4	58.6	59.8	58.1
Long Term												
Full Simulation Period[a]	57.2	55.3	51.4	49.2	50.4	53.2	53.2	55.1	59.0	62.9	62.7	61.5
Water Year Types[b,c]												
Wet (23%)	54.3	53.4	50.5	48.7	49.3	50.2	51.3	53.2	55.2	59.5	59.4	57.8
Above Normal (24%)	56.6	54.9	51.2	49.0	49.9	52.7	52.4	54.6	56.3	61.9	62.2	61.1
Below Normal (10%)	56.0	54.7	51.0	48.9	50.3	53.4	52.9	54.2	58.8	63.3	62.4	61.0
Dry (16%)	57.8	56.0	51.6	49.5	50.9	54.5	54.0	55.4	61.2	64.1	63.5	62.4
Critical (27%)	60.5	57.2	52.2	49.8	51.6	55.2	55.2	57.4	63.4	65.9	65.5	64.6

Proposed Action 011519

Statistic	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
	Monthly Temperature (DEG-F)											
Probability of Exceedance												
10%	59.7	57.0	52.7	51.1	52.6	55.7	56.3	58.6	65.2	67.8	67.2	64.5
20%	58.0	56.1	52.5	50.5	51.9	55.1	55.6	58.1	64.6	66.5	65.6	63.2
30%	57.2	55.5	52.0	50.0	51.3	54.7	54.6	56.7	63.3	65.4	64.7	62.6
40%	56.6	54.9	51.5	49.5	50.9	54.3	53.8	55.8	61.9	64.1	63.1	62.0
50%	56.2	54.6	51.0	49.1	50.5	53.7	52.9	54.8	60.0	63.5	62.7	61.2
60%	55.8	54.4	50.6	48.9	50.1	53.1	52.5	54.3	59.3	63.2	62.1	60.8
70%	55.1	53.9	50.4	48.4	49.5	51.9	52.0	54.0	58.7	62.8	61.9	60.2
80%	54.7	53.5	50.0	47.9	49.3	50.6	51.4	53.4	56.2	61.9	61.6	60.0
90%	53.9	53.2	49.7	47.4	48.5	49.4	50.7	52.8	54.7	60.9	60.4	58.3
Long Term												
Full Simulation Period[a]	56.7	55.0	51.2	49.2	50.5	53.2	53.3	55.4	60.3	63.8	63.2	61.5
Water Year Types[b,c]												
Wet (23%)	54.5	53.6	50.6	48.7	49.3	49.9	51.4	53.3	54.7	59.7	59.7	58.0
Above Normal (24%)	56.7	54.8	51.1	49.1	50.0	52.9	51.9	54.1	59.3	63.2	62.6	61.5
Below Normal (10%)	55.6	54.4	50.9	48.8	50.2	53.5	52.8	54.2	59.4	63.4	62.3	60.9
Dry (16%)	57.0	55.3	51.3	49.4	51.1	54.5	54.3	56.3	62.6	64.6	63.3	61.9
Critical (27%)	58.8	56.4	52.0	49.7	51.8	55.4	55.9	58.5	65.0	67.4	66.9	64.5

Proposed Action 011519 minus Current Operations 011319

	Monthly Temperature (DEG-F)											
Statistic	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Probability of Exceedance[a]												
10%	-1.9	-1.7	-0.7	-0.2	**0.1**	-0.1	**1.0**	**0.9**	**1.5**	**2.4**	**1.8**	-0.1
20%	-1.3	-0.9	-0.1	-0.3	**0.2**	**0.1**	**0.8**	**1.3**	**2.2**	**1.9**	**1.4**	-0.1
30%	-0.3	-0.6	-0.2	-0.1	**0.1**	**0.1**	**0.5**	**0.7**	**1.7**	**1.3**	**1.2**	**0.6**
40%	-0.3	-0.1	0.0	-0.1	**0.1**	**0.3**	**0.1**	**0.5**	**1.3**	**0.4**	**0.2**	**0.4**
50%	-0.2	-0.2	-0.1	**0.0**	**0.1**	0.0	-0.2	-0.1	**0.8**	**0.3**	**0.1**	**0.0**
60%	-0.1	-0.2	-0.1	**0.1**	**0.0**	-0.1	-0.2	-0.1	**2.7**	**0.6**	-0.1	**0.1**
70%	-0.2	-0.2	0.0	**0.0**	-0.1	-0.2	-0.2	**0.0**	**2.8**	**0.7**	**0.1**	-0.3
80%	-0.1	-0.1	-0.1	**0.0**	**0.1**	-0.4	-0.5	-0.2	**0.9**	**0.3**	**0.1**	**0.1**
90%	-0.1	**0.5**	-0.1	**0.3**	**0.1**	-0.2	-0.1	**0.2**	**0.2**	**2.3**	**0.6**	**0.1**
Long Term												
Full Simulation Period[a]	-0.6	-0.3	-0.1	0.0	**0.1**	**0.0**	**0.1**	**0.3**	**1.3**	**0.9**	**0.5**	**0.0**
Water Year Types[b,c]												
Wet (23%)	**0.1**	**0.2**	**0.1**	0.0	0.0	-0.4	**0.0**	**0.1**	-0.5	**0.2**	**0.3**	**0.2**
Above Normal (24%)	**0.1**	-0.1	-0.1	**0.1**	**0.2**	**0.2**	-0.5	-0.5	**3.0**	**1.4**	**0.4**	**0.4**
Below Normal (10%)	-0.4	-0.3	-0.1	-0.1	-0.1	**0.1**	-0.1	0.0	**0.6**	**0.1**	-0.1	-0.1
Dry (16%)	-0.9	-0.7	-0.3	-0.1	**0.2**	**0.0**	**0.3**	**0.9**	**1.4**	**0.5**	-0.2	-0.5
Critical (27%)	-1.7	-0.8	-0.2	-0.1	**0.1**	**0.1**	**0.7**	**1.1**	**1.6**	**1.5**	**1.4**	-0.1

a Based on the 82-year simulation period.
b As defined by the San Joaquin Valley 60-20-20 Index Water Year Hydrologic Classification (State Water Resources Control Board 1999).
c These results are displayed with calendar year - year type sorting.
d All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.
e These are draft results meant for qualitative analysis and are subject to revision.
f New Melones forecasts are used as the basis of water operations.

Source: ROC on LTO biological assessment: Table 23-3 from Appendix D, Attachment 3-4

Modeled temperatures are likely cooler than will be realized under actual operations based on a comparison of model results under the current operating scenario to recent measured temperatures on the Stanislaus River. For example, the current operating scenario scenario modeling results in Table 118 indicate that average monthly temperatures at Goodwin Dam exceed 54°F 50 percent of the time in July, 60 percent of the time in August, and 70 percent of the time in September. Actual temperatures from 2009 to 2018 at Goodwin Dam (Figure 126) show that even minimum daily water temperatures exceeded 54°F for most of the summer in most years of that 10-year period, except for 2011 and 2017, both wet years with high summertime releases. This snapshot of recent temperatures compared to modeled temperatures under the climate change scenario is intended as a screening-level check on the modeled results. NMFS acknowledges that differences between modeled and recent temperatures could be due to differences in the frequency of hydrology and meteorology in the full CalSimII period and the 2009 to 2018 period.

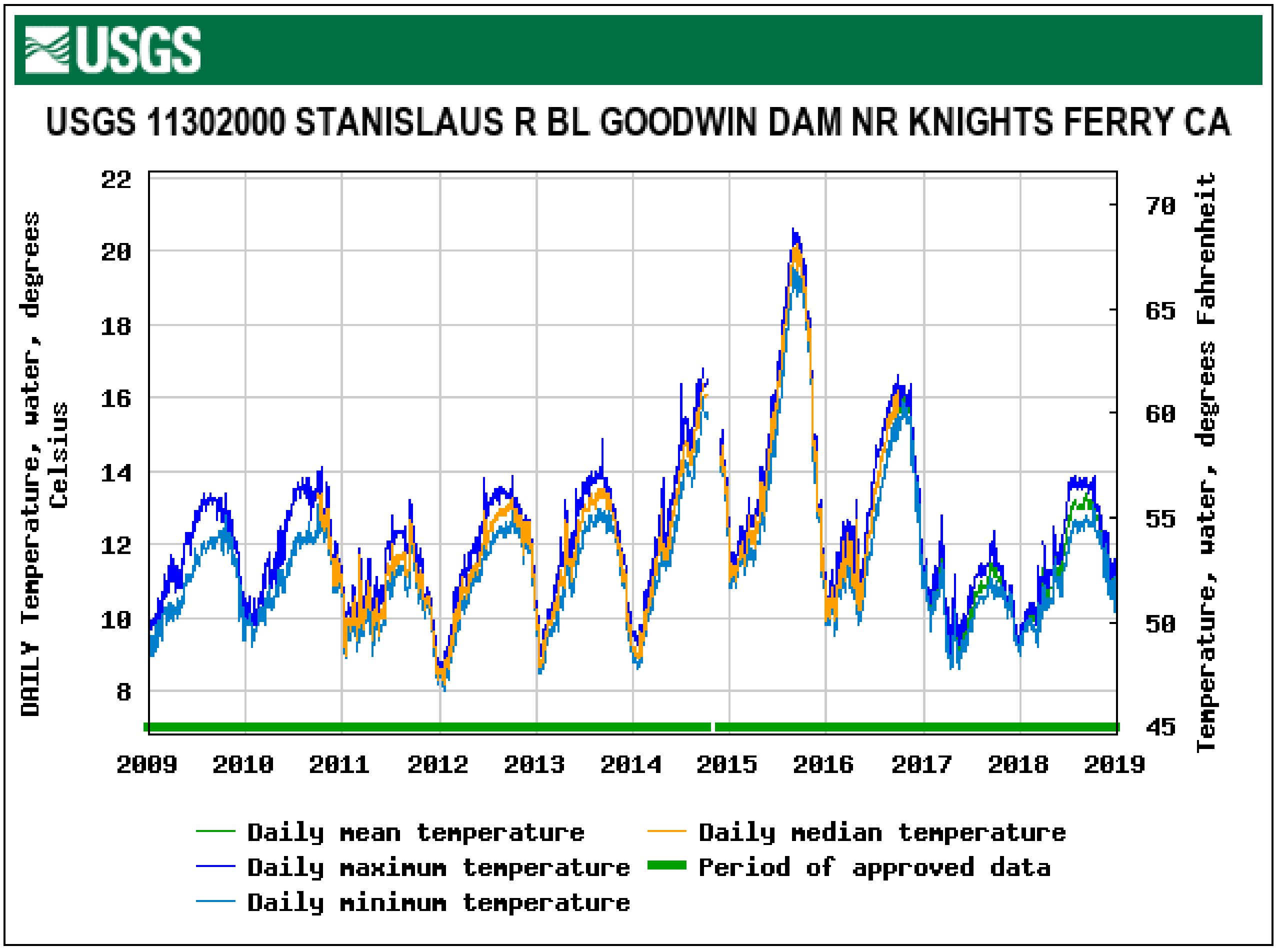


Figure 126. Minimum, mean, and maximum daily water temperatures at Goodwin Dam for 2009 to 2018.
Source: USGS gauge 11302000, National Water Information System: USGS National Water Information System)

8.7.1.5 Review of Stanislaus River floodplain inundation under the proposed action

The construction of New Melones Dam reduced the frequency and extent of overbank flooding which, in combination with channel incision and the geomorphic effects of sediment starvation below dams, has isolated floodplains from the river channel, leading to the loss of important habitats and ecological functions (Schneider et al. 2000). While no specific floodplain inundation targets are in the proposed action, floodplain inundation in the proposed action can be evaluated as a function of the modeled flows under the proposed action. There are some minor decreases in inundated habitat on the Stanislaus River in the proposed action compared to the current operating scenario (Table 37-3 in the ROC on LTO biological assessment), primarily in May and June. Because these estimates are based on average monthly flow output from CalSimII, these results are used as a screening tool to compare the potential for changes to rearing habitat. Realized flows will likely show greater variability with higher peaks (and thus more inundated acres during peak flows) and perhaps somewhat lower base flows (and thus possibly fewer inundated acres during base flows).

Table 119. Exceedance tables of inundated floodplain acres on the Stanislaus River under the proposed action and current operating scenario scenarios.

COS5												
Probability of Exceedance	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
10%	5	0	0	0	0	0	3	4	0	0	0	0
20%	5	0	0	0	0	0	7	5	0	0	0	0
30%	6	0	0	0	0	0	8	7	1	0	0	0
40%	6	0	0	0	0	0	9	11	2	0	0	0
50%	8	0	0	0	0	0	79	40	2	0	0	0
60%	8	0	0	0	0	0	79	40	10	1	0	0
70%	8	0	0	0	0	3	114	60	11	1	0	0
80%	8	0	0	0	2	108	114	114	24	1	1	1
90%	9	1	1	1	11	132	129	178	28	3	2	2
Mean	9	8	19	36	38	57	64	54	21	10	7	9

PA20												
Probability of Exceedance	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
10%	5	0	0	0	0	0	3	2	0	0	0	0
20%	5	0	0	0	0	0	3	2	0	0	0	0
30%	6	0	0	0	0	0	8	6	0	0	0	0
40%	6	0	0	0	0	0	12	9	0	0	0	0
50%	8	0	0	0	0	0	79	40	2	0	0	0
60%	8	0	0	0	0	0	79	40	2	0	0	0
70%	8	0	0	0	0	7	114	40	2	0	0	0
80%	8	0	0	0	1	108	114	114	11	1	1	1
90%	8	0	1	7	259	126	118	114	11	1	1	1
Mean	8	9	15	39	60	57	65	47	24	15	7	9

PA20 minus COS5												
Probability of Exceedance	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
10%	0	0	0	0	0	0	0	-2	0	0	0	0
20%	0	0	0	0	0	0	-4	-3	0	0	0	0
30%	0	0	0	0	0	0	0	-1	0	0	0	0
40%	0	0	0	0	0	0	3	-2	-1	0	0	0
50%	0	0	0	0	0	0	0	0	0	0	0	0
60%	0	0	0	0	0	0	0	0	-8	0	0	0
70%	0	0	0	0	0	4	0	-20	-10	0	0	0
80%	0	0	0	0	-1	0	0	0	-12	0	0	0
90%	-1	-1	0	6	249	-6	-10	-64	-17	-2	-1	-1
Mean	0	0	-4	3	22	0	1	-7	4	4	0	0

Source: Supplemental modeling provided by Reclamation in support of the ROC on LTO biological assessment

Reclamation provided supplemental information on weighted usable area for CCV steelhead fry and juveniles in various reaches of the Stanislaus River, and additional information on rearing habitat as a function of Stanislaus River flow is provided in Bowen et al. (2012). The proposed action has the potential to reduce inundated habitat during base flows, which would affect species and their critical habitat.

8.7.1.5.1 CCV Steelhead Exposure, Response, and Risk

8.7.1.5.1.1 CCV Steelhead Exposure

For the purposes of this analysis, "exposure" is defined as the temporal and spatial co-occurrence of a CCV steelhead life stage and the stressors associated with the proposed action. CCV steelhead exhibit very diverse life histories, and adults and juveniles might be present in the Stanislaus River at any time of year. Since some components of the proposed action occur year round, CCV steelhead may be affected by the action whenever they are present in the Stanislaus River. The most likely windows of CCV steelhead exposure are summarized in Figure 127.

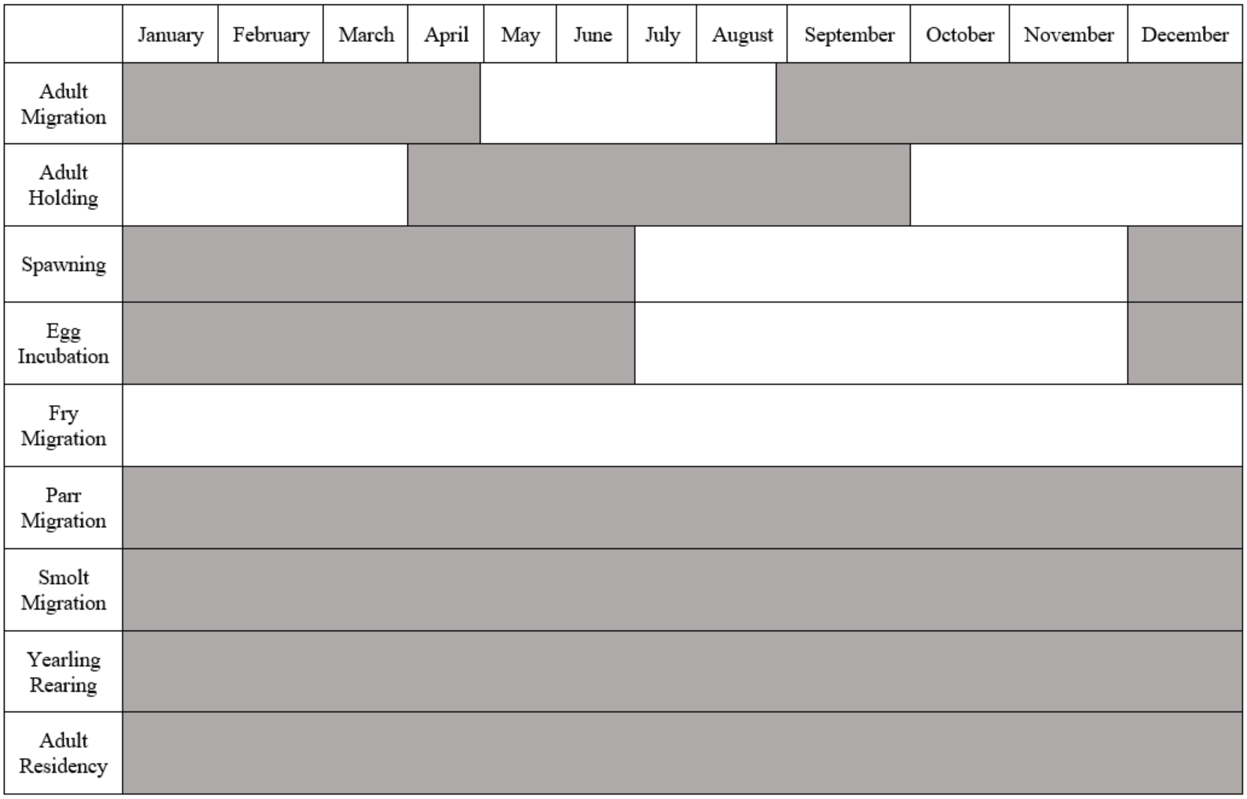


Figure 127. Timing of steelhead migration by life stage on the Stanislaus River.

Source: Excerpt of Figure 8 of Stanislaus River Scientific Evaluation Process (SEP) Team (2019)

For this analysis, the following life history timing is assumed:

- Spawning: December – February
- Egg incubation to fry emergence: December – June
- Juvenile rearing: year round
- Juvenile migration: Primarily February – May
- Smoltification: January – June
- Adult migration: October – March

The CCV steelhead adult immigration life stage occurs throughout the entire lower Stanislaus River. Based on reports that “young trout began to emerge from the gravel at the upper river sites by April” (Kennedy and Cannon 2002), it is reasonable to conclude that most spawning occurs from Goodwin Dam (river mile 59) to Knights Ferry (river mile 54) with some spawning possible downstream to Orange Blossom Bridge near Oakdale (river mile 47). The juvenile life stage occurs throughout the entire river, with rearing generally occurring in the vicinity of the upstream areas used for spawning. Observations during 2005 to 2007 snorkel surveys indicate that young CCV steelhead had the highest densities in September to October and April to July, and were most abundant in the upper and middle reaches of the river (Kennedy 2008); Figure 128 and Figure 129). Young salmon and young and yearling trout were found in significantly higher densities in experimental sites where gravel had been placed in the river to create riffle habitat, which indicates that experimental sites create beneficial habitat for all young salmonids.

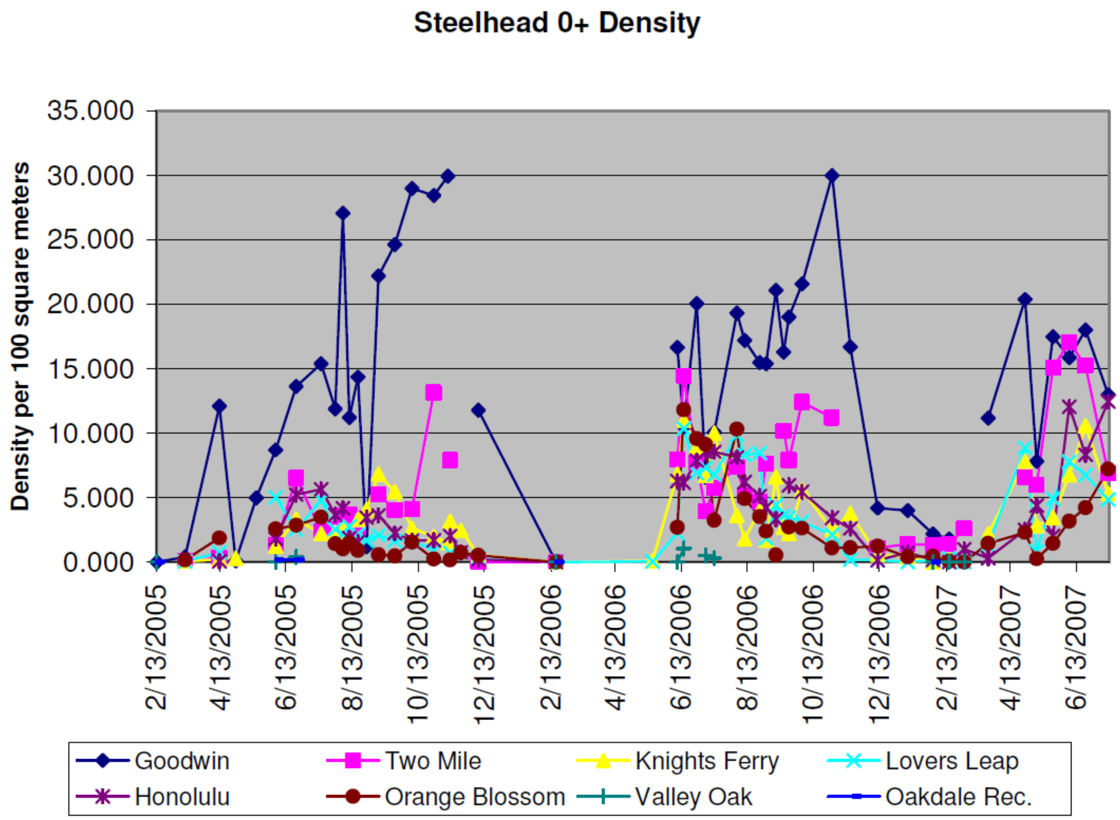


Figure 128. Average density of young-of-year O. mykiss at eight sampling sites from February 2005 to July 2007.

Source: Figure 6 in Kennedy (2008)

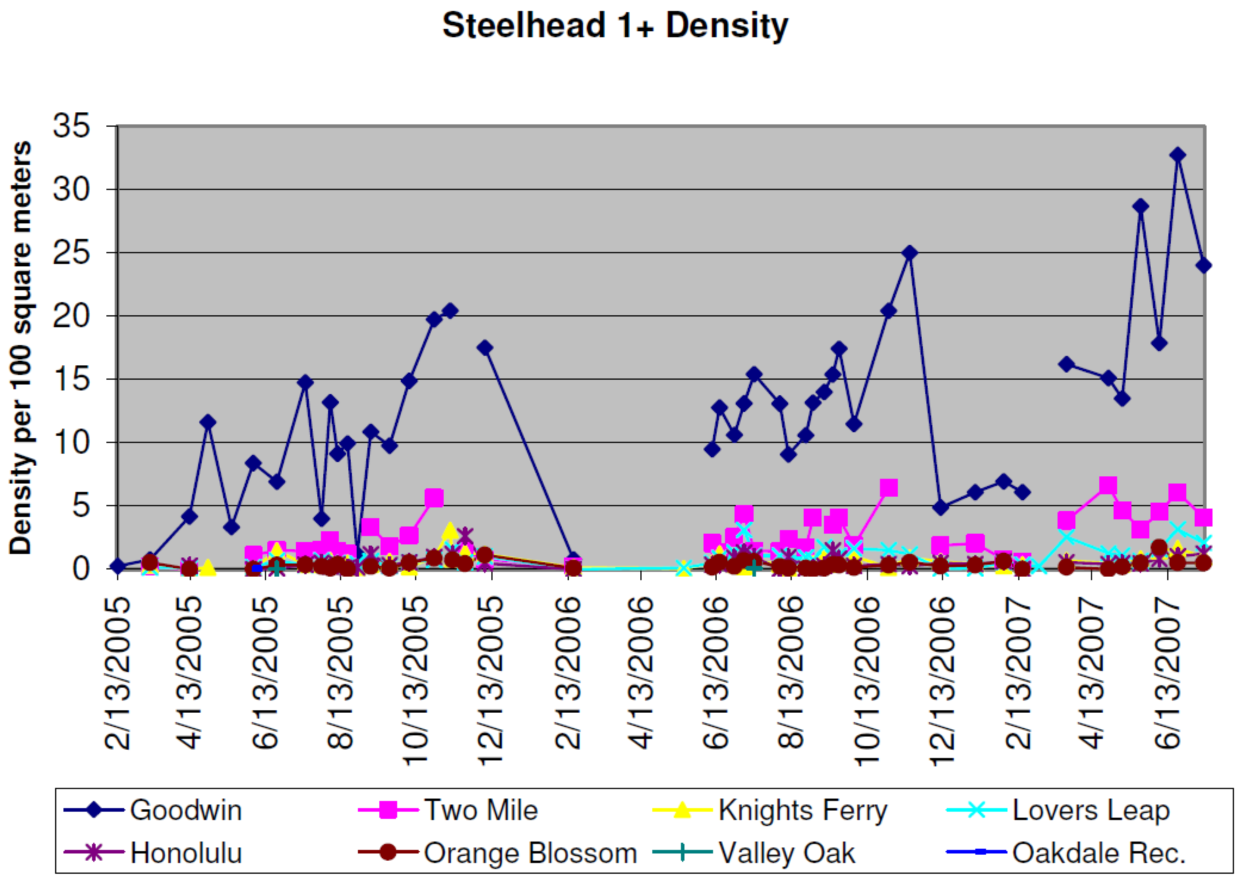


Figure 129. Average density of yearling or older O. mykiss at eight sampling sites from February 2005 to July 2007.

Source: Figure 7 in Kennedy (2008)

There are no temperature control devices on any of the East Side Division facilities, so the only mechanism (aside from occasional flexibility to release from the gates at Tulloch Dam and the rare flexibility to use the low-level outlet at New Melones Dam) for temperature management is direct flow management. While it can take a lot of water to buffer temperature exceedances of long duration and large magnitude, less water would be required to buffer temperature exceedances of short duration and low magnitude. However, the proposed action does not commit to any temperature criteria for the Stanislaus River. As described above, CCV steelhead will continue to be subjected to occasional sublethal and lethal temperature effects in the Stanislaus River from the egg through smolt stages and potentially as adults.

Aceituno (1993) applied the instream flow incremental methodology to the Stanislaus River between Riverbank and Goodwin Dam (24 river miles) and determined that flows of 200 cfs provided maximum weighted usable area for steelhead spawning. The stepped release plan flow schedules have minimum flows of at least 200 cfs from October through April in all water year types except Critical water year types. The modeling results show that flows will not drop below 200 cfs, even in June through September of Critical water years, as a result of dissolved oxygen requirement.

Because the existing dams prevent access to historical habitat, the proposed operations of the dams control the quality and quantity of available alternative habitat below Goodwin Dam and the suitability of the physical conditions to support CCV steelhead at various life history stages. Survival or growth of CCV steelhead may be affected by operations of the East Side Division in the following ways:

- Operational releases control extent of cool water habitat available below Goodwin Dam.
- Operational release levels control the quantity and functionality of instream habitat for spawning, egg incubation, juvenile rearing and smoltification.
- Operational releases are typically lower than flows under the natural hydrograph, requiring smolting juveniles to expend more energy to outmigrate and lower stream velocities increase the exposure of juveniles and smolts to predation.

The proposed operation of the East Side Division would continue to modify the hydrograph from the unimpaired flow pattern with which CCV steelhead evolved, consistent with current conditions. Such modifications are likely to continue to affect survival and growth of CCV steelhead in the following ways:

- Peak flood flows are dampened, reducing floodplain and side-channel inundation and impairing rearing ability including production of food;
- Flow variability is muted, eliminating migratory cues that prompt migration and anadromy;
- Flow variability is muted, causing channel incision, reducing available rearing habitat, simplifying channel complexity and allowing land use encroachment into riverside habitats; and Channel forming flows are reduced or eliminated, resulting in fossilization of gravel bars and degradation of spawning habitat.

The proposed action is likely to result in lower flows, particularly in the months of April through June, compared to current conditions. These changes are likely to affect the growth and survival of CCV steelhead as described below.

8.7.1.5.1.2 CCV Steelhead Response

Now that the potential exposure of CCV steelhead to effects of seasonal operations and the stepped release plan has been described, the next step is to assess how these fish are likely to respond to the proposed action-related stressors. Life stage-specific responses to specific stressors related to the proposed action are described in this section.

Water temperature can be a stressor in the Stanislaus River, particularly in summer months. The literature and scientific basis for life stage related temperature requirements for CCV steelhead are described in Table 16. Discussions of temperature suitability for salmonids in this region, and summary and evaluation of water temperature conditions at finer temporal scales are provided in Stanislaus River Scientific Evaluation Process (SEP) Team (2019) and Deas (2004).

Information on maximum temperatures was not provided in the ROC on LTO biological assessment; rather, the modeling results summarize monthly temperatures. Accordingly, this analysis evaluates modeled monthly temperatures at Orange Blossom Bridge under the proposed action (Table 120).

All the temperature model outputs are based on assumptions of daily flow equivalent to the monthly CalSimII inputs, so do not fully capture the flow (and associated temperature) variability expected during real-time operations. Temperature requirements are based on the seven-day average of the daily maximum temperature, or 7DADM. A rough evaluation of temperature suitability under the proposed action at Orange Blossom Bridge is provided based on monthly averages of daily average temperature.

Table 120. Salmonid temperature requirements by life stage.

Life Stage & Timing	Temperature Criterion	General evaluation of water temperature suitability at Orange Blossom Bridge based on monthly averages of daily average temperature rather than 7DADM
Salmon/trout juvenile rearing (year-round)	61°F 7DADM	Water temperatures are generally suitable (≤ 61°F) for juvenile rearing during October through May, but exceed 61°F in the warmest 40 percent of years in June, 80 percent of years in July and August, and 50 percent of years in September.
Salmon/trout migration plus non-core juvenile rearing (year-round)	64°F 7DADM	Water temperatures are generally suitable (≤ 64°F) for migration and non-core juvenile rearing during October through May, but exceed 64°F in the warmest 20 percent of years in June, 40 percent of years in July, 30 percent of years in August, and 10 percent of years in September.
Salmon/trout migration (October – March)	68°F 7DADM	Water temperatures are generally suitable (≤ 68°F) for adult CCV steelhead migration into (and for kelt outmigration from) the Stanislaus River in all months. Water temperatures approach 68°F in July and August of the warmest 10 percent of years, but few, if any, CCV steelhead are expected to be migrating in those months.
Salmon/Trout Spawning, Egg Incubation, and Fry Emergence (December – June)	55°F 7DADM[22]	Water temperatures are generally suitable (≤ 55°F) for spawning and incubation in December, January, and February. Water temperatures exceed 55°F in the warmest 20 percent of years in March and April, 40 percent of years in May, and 80 percent of years in June. CCV steelhead that spawn later in the season, or farther downstream will have reduced or even failed reproductive success, leading to reduced productivity and also reduce diversity in life-history timing by truncating the timing and area available for successful spawning.

[22] Steelhead eggs incubating in the redds in the river may need colder temperatures than 55°F to have high survival. Martin et al. (2016) found strong evidence that significant thermal mortality occurred during the embryonic stage in Chinook salmon in some years due to a >5°F reduction in thermal tolerance in the field compared to laboratory studies due to differences in oxygen supply in lab and field contexts. This issue likely applies to what is known about the relationship between thermal tolerance and steelhead survival given that, like Chinook salmon, steelhead eggs incubate under the water column in spawning gravels.

Life Stage & Timing	Temperature Criterion	General evaluation of water temperature suitability at Orange Blossom Bridge based on monthly averages of daily average temperature rather than 7DADM
Steelhead Smoltification (January – June)	57°F 7DADM	This life history stage is uniquely important for the expression of anadromy in *O. mykiss*. Water temperatures are generally suitable (≤ 57°F) for steelhead smoltification in January, February, March, and April. Water temperatures exceed 57°F in the warmest 20 percent of years in May and 70 percent of years in June. The proposed operations will truncate the successful smoltification of late developing smolts.

Source: U.S. EPA's Guidance for Pacific Northwest State and Tribal Temperature Water Quality Standards (U.S. Environmental Protection Agency 2003).

Relative to temperatures at Orange Blossom Bridge (except during the winter when water may cool as it moves downstream), temperatures will generally be cooler at Goodwin Dam and warmer at the confluence to the San Joaquin River. Most spawning and core juvenile rearing occurs at or above Orange Blossom Bridge. CCV steelhead juveniles can likely avoid, to some degree, unsuitable rearing water temperatures at Orange Blossom Bridge by moving farther upstream, but that does reflect a reduction of suitable rearing habitat and may result in increased competition for rearing habitat and food and reductions in growth or survival. Late-spawning CCV steelhead adults can likely avoid, to some degree, unsuitable spawning water temperatures at Orange Blossom Bridge by moving farther upstream. However, because conditions are generally suitable as far downstream as Orange Blossom Bridge from December to February, eggs spawned near Orange Blossom Bridge in those months may later experience unsuitable water temperatures during egg incubation or as alevins that could lead to reductions in survival. CCV steelhead juveniles may be able to reach suitable smoltification temperatures in late spring upstream of Orange Blossom Bridge, but it is uncertain whether CCV steelhead juveniles rearing in the vicinity of Orange Blossom Bridge would seek cooler temperatures suitable for smoltification.

There are no temperature control devices on any of the East Side Division facilities, so the only mechanism (aside from occasional flexibility to release from the gates at Tulloch Dam and the rare flexibility -- during severe drought -- to use the low-level outlet at New Melones Dam) for temperature management is direct flow management. While it can take a lot of water to buffer temperature exceedances of long duration and large magnitude, less water would be required to buffer temperature exceedances of short duration and low magnitude. However, the proposed action does not propose temperature criteria for the Stanislaus River. As described above, CCV steelhead will be subjected to occasional sublethal and lethal temperature effects in the Stanislaus River from the egg through smolt stages and potentially as adults, particularly in the vicinity of Orange Blossom Bridge and downstream.

As noted earlier, while Reclamation provided supplemental information on the estimated amount of inundated floodplain area and weighted usable area in the Stanislaus River. Inundated floodplain can provide areas with shelter and cover during high flow events, as well as, provide rich foraging habitat for CCV steelhead fry and juveniles in various reaches of the Stanislaus River. Using the SRH-2D hydraulic model for the lower 60.3 miles of the Stanislaus River, the total floodplain surface area that would be inundated in water years 1922 through 2003 was estimated for the proposed action and current operating scenario (Table 8.1.6-9). In general, modeling results show that operations under the proposed action will reduce the amount of inundated floodplain in some years during the months of April, May and June. The amount and quality of juvenile steelhead rearing habitat associated with inundated areas was not determined for the modeled area, so Reclamation's consultant assumed the surface area of high quality habitat was 27 percent of the total inundated area, based on results from the San Joaquin River, reported in San Joaquin River Restoration Program (2012). Additional information on rearing habitat as a function of Stanislaus River flow is provided in Bowen et al. (2012).

Past operations of the East Side Division have eliminated channel forming flows and geomorphic processes that maintain and enhance CCV steelhead spawning beds and juvenile rearing areas associated with floodplains and channel complexity (Kondolf et al. 2001). Since the operation of New Melones Dam, channel-forming flows above 8,000 cfs have been reduced to zero (as intended to avoid flooding), and mobilizing flows in the 5,000 to 8,000 cfs range occur very rarely. Channel-forming flows are important to rejuvenate spawning beds and floodplain rearing habitat and to recruit allochthonous nutrients and large wood into the river. Floodplain and side channel habitats provide important juvenile refugia and food resources for juvenile salmonid growth and rearing (Heady and Merz 2007; Jeffres et al. 2008; Sommer et al. 2001a; Sommer et al. 2005). The stepped release plan does not propose flows above 3,000 cfs, so flows of at least 5,000 cfs under the proposed action will only occur during flood control. The low frequency of these channel-forming high flow events will continue under the proposed action and will result in continued degradation of spawning habitat and rearing habitat. Reduction and lack of recruitment of spawning gravels directly reduces the productivity of the species by reducing the amount of usable habitat area and causing direct egg mortality. Lower productivity leads to a reduction in abundance.

Muting of winter storm flows and the spring/summer snowmelt in the seasonal hydrograph reduces the frequency and magnitude of flows that may cue anadromy, cue outmigration, and support more successful outmigration by providing a "conveyance" flow that may increase outmigration speed (or match an outmigration speed with lower energy expenditures) and survival. Zeug et al. (2014) documented a positive relationship between a survival index and flow for juvenile Chinook salmon on the Stanislaus River, (Figure 130) based on data from rotary screw traps near Oakdale (river mile 40) and Caswell (river mile 8). However, a 3-year study using radio-tagged fall-run Chinook salmon on the Stanislaus River (Zeug et al. 2016) offered somewhat contrary results. The authors noted, "Flow did not have a significant effect on survival; however, because some fish exhibited holding behavior, the stationary detection models were biased toward actively migrating fish. The mobile detection models suggested that there was a greater probability of fish transitioning out of the study reach when discharge was higher, which is supported by previous studies in this reach." The study years 2012 to 2014 had relatively dry hydrology and the variation in average flows tested ranged only from 12-77 cms (424-2,719 cfs), which does not include the highest flows required under the NMFS 2009 Opinion (short periods of 5,000 cfs in Wet water year types), and is slightly short of the highest flows required under the stepped release plan (short periods of 3,000 cfs in Wet water year types).

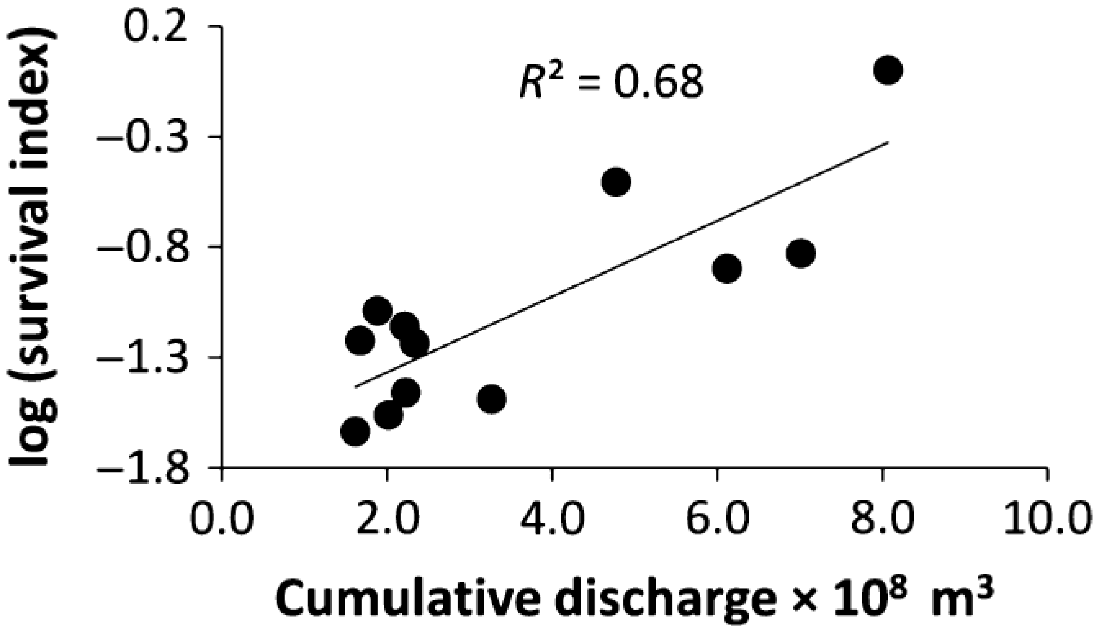


Figure 130. Relationship between the juvenile Chinook salmon survival index and cumulative discharge in cubic meters per second (cms) for study years 2012 to 2014.

Source: Top left panel of Figure 3 in Zeug et al. (2014)

8.7.1.5.1.3 CCV Steelhead Risk

Based on the effects to CCV steelhead associated with the proposed action component described above, fitness consequences to individuals include the potential for reduced reproductive success during spawning, reduced survival during egg incubation, reduced survival and growth during juvenile rearing, and reduced survival and growth during smolt emigration. Additionally, conditions may continue to restrict the window of successful outmigration of individuals and, thus, limit the diversity of outmigration timing for the population.

8.7.1.6 Alteration of Stanislaus Dissolved Oxygen Requirement

Reclamation is required to meet dissolved oxygen standards on the lower Stanislaus River at Ripon for species protection as required by Reclamation's water rights in conjunction with the local basin plan. Reclamation currently operates to a 7.0 milligrams per liter (mg/L) dissolved oxygen requirement at Ripon year-round. Reclamation monitors and reports daily dissolved oxygen levels at Ripon, as required by the State Water Resources Control Board (D-1422, p. 32). Maintaining dissolved oxygen concentrations above 7.0 mg/L in the Stanislaus River at Ripon requires additional releases from New Melones Dam generally only during low flow, in the summer and early fall. Reclamation proposes to move the compliance location from Ripon to Orange Blossom Bridge, approximately 31 miles upstream, from June 1 to September 30.

Changing the compliance point from Ripon to Orange Blossom Bridge from June 1 to September 30 would decrease dissolved oxygen downstream of Orange Blossum Bridge to Ripon. Cramer Fish Sciences (2006a-d as cited in ROC on LTO biological assessment) indicated that dissolved oxygen concentrations at the Stanislaus River Weir (approximately 15 miles upstream from Ripon) can be 0.5 to 1 mg/L higher than those measured at Ripon. The dissolved oxygen is approximately 1.0 to 2.0 mg/L higher at Orange Blossom Bridge than at Ripon, so at this rate, if the dissolved oxygen standard of 7.0 mg/L is moved to Orange Blossom Bridge, then the dissolved oxygen at Ripon (31 miles downstream) would be approximately 5.0 to 6.0 mg/L.

8.7.1.6.1 CCV Steelhead Exposure, Response, and Risk

8.7.1.6.1.1 CCV Steelhead Exposure

All current stocks of CCV steelhead have a winter run timing, although summer steelhead may have been present prior to the completion of major dams in the Sacramento River system (McEwan and Jackson 1996). The life history strategies of CCV steelhead are extremely variable between individuals, and it is important to take into account that CCV steelhead are iteroparous, and can spawn more than once in their lifetime. Therefore, timing of upstream and downstream migrating adult CCV steelhead (kelts) should be considered. San Joaquin River origin adult CCV steelhead peak in November through January in the Delta (California Department of Fish and Game 2007), and migrate up the San Joaquin River and its tributaries during a peak timing of November to January. There are limited data on the residence time and run timing of adult CCV steelhead of both Sacramento and San Joaquin River origin in the Delta. Data on the frequency of occurrence and downstream run timing of CCV steelhead kelts throughout the Central Valley, and the Delta specifically, are very limited.

Based on studies in the Stanislaus River from Oakdale to Goodwin Dam, CCV steelhead are primarily present upstream of Orange Blossom Bridge (Kennedy 2008; Kennedy and Cannon 2005; Kennedy and Cannon 2002) where temperatures and dissolved oxygen levels are suitable.

During these snorkel surveys (in 2005, 2006, and 2007), young trout had the highest densities in September to October and April to July (Kennedy 2008). Therefore, juvenile steelhead may be present in the Stanislaus River when dissolved oxygen would be reduced to less than 7.0 mg/L. However, since juvenile steelhead are most abundant in the upper and middle reaches of the river, they are not expected to be present below Orange Blossom Bridge. Adult rainbow trout, including some that appeared to be steelhead, were observed sporadically in the river during summer surveys. All observations of adults were above Orange Blossom Bridge. Similar to juvenile, adult steelhead are not expected to be present below Orange Blossom Bridge during the warm summer months when dissolved oxygen would be less than 7.0 mg/L.

8.7.1.6.1.2 CCV Steelhead Responses

Adequate water quality, including temperature, salinity, dissolved oxygen concentrations, and other chemical characteristics necessary for normal behavior, growth, and viability of all salmonid life stages are required for the proper functioning of salmonid species. Reduced levels of dissolved oxygen can impact growth and development of different steelhead life stages. Such impacts can affect fitness and survival by altering egg incubation periods, decreasing the size of fry, increasing the likelihood of predation, and decreasing feeding activity. Extremely low dissolved oxygen concentrations can be lethal to salmonids (California Regional Water Quality Control Board 2005). The upstream migration of adult salmonids requires swimming long distances and uses high expenditures of energy, which requires sufficient levels of dissolved oxygen. According to Hallock et al. (1970), migrating adult Chinook salmon in the San Joaquin

River exhibited an avoidance response when dissolved oxygen was below 4.2 mg/L, and most Chinook salmon waited to migrate until dissolved oxygen levels were at least 5 mg/L. Salmonids may be able to survive when dissolved oxygen concentrations are low (<5 mg/L), but growth, food conversion efficiency, and swimming performance will be negatively affected (Bjornn and Reiser 1991; California Regional Water Quality Control Board 2005) referred to numerous studies and reported no impairment to rearing salmonids if dissolved oxygen concentrations averaged 9 mg/L, while dissolved oxygen levels of 6.5 mg/L result in symptoms of oxygen distress. Field and laboratory studies have found that juvenile salmonids consistently avoid dissolved oxygen concentrations of 5 mg/L and lower, and there is some indication that avoidance is triggered at concentrations as high as 6 mg/L.

Changing the dissolved oxygen requirement location on the Stanislaus River from Ripon upstream to Orange Blossom Bridge would likely decrease dissolved oxygen downstream of the Orange Blossom Bridge by approximately 1 to 2 mg/L. This may result in juveniles avoiding the area during rearing or downstream migration. Adults would likely not be affected since they are not likely to avoid the area unless dissolved oxygen is below 4.2 mg/L, and adults are known to be present above Orange Blossom Bridge, where dissolved oxygen would be at least 7.0 mg/L.

8.7.1.6.1.3 Risk to CCV Steelhead

Adult CCV steelhead may be present in the Stanislaus River during the summer months when dissolved oxygen may be lower at Ripon as a result of the proposed action, however, adult CCV steelhead have only been observed holding upstream of Orange Blossom Bridge, 31 miles upstream of the Ripon compliance point where dissolved oxygen is greater than 7.0 mg/L. Therefore, adult CCV steelhead are not expected to be exposed to the effects of altering the dissolved oxygen requirements at Ripon.

Juvenile CCV steelhead may also be present in the Stanislaus River during the summer months while rearing or migrating downstream. Juvenile CCV steelhead observations during snorkel surveys were primarily upstream of Orange Blossom Bridge. Though a few juvenile CCV steelhead may be migrating past Ripon during the time the dissolved oxygen requirement is relaxed, the time of exposure to potentially lower levels (5 to 6 mg/L) of dissolved oxygen is expected to be short term. Juvenile salmonids are known to avoid migrating when dissolved oxygen is 5.0 mg/L or lower, and there may be oxygen distress from dissolved oxygen of 6.5 mg/L or less (California Regional Water Quality Control Board 2005). Since most juvenile CCV steelhead will be upstream during summer months when dissolved oxygen is low, they would not be negatively affected by the proposed action component. However, the small number of juveniles migrating past Ripon during the summer months may avoid areas where dissolved oxygen is less than 5.0 mg/L, which would delay their outmigration. Fish that pass through the area rather than avoid it would be exposed to short term oxygen distress. These responses would result in reduced fitness levels.

8.7.1.7 Conservation Measures

Reclamation included two conservation measures as part of its proposed action to support CCV steelhead in the Stanislaus River. These measures are assessed in this section.

8.7.1.7.1 Spawning and Rearing Habitat Restoration

Reclamation proposes the following commitments to habitat restoration on the Stanislaus River:

- **Spawning Habitat:** Under the CVPIA (b)(13) program, Reclamation's annual goal of gravel placement is approximately 4,500 tons in the Stanislaus River.
- **Rearing Habitat:** Reclamation proposes to construct an additional 50 acres of rearing habitat adjacent to the Stanislaus River by 2030.

A summary of restoration projects completed on the Stanislaus River since 2009 is provided in Table 121.

a) *COMPLETED gravel augmentation projects (for spawning habitat at all locations; some gravel placed at the cable crossing in Goodwin Canyon intended for mobilization and downstream placement by river flows)*

Table 121. Summary of completed (since 2009) and potential habitat restoration projects on the Stanislaus River.

COMPLETED Gravel Project	Project extent
Goodwin Canyon at cable crossing - 2011	2,941 cubic yards
Goodwin Canyon at float tube pool - 2012	1,765 cubic yards
Goodwin Canyon at cable crossing - 2015	4,706 cubic yards
Main channel and floodplain bench at Honolulu Bar - 2012	8,000 cubic yards total used for spawning riffles in main channel and 0.7 acre floodplain bench
Buttonbush - 2017	2,838 cubic yards
Rodden Road - 2018	1,250 cubic yards

b) *COMPLETED floodplain and side-channel restoration projects (for improved rearing habitat, improved migratory habitat, improved connectivity to avoid stranding)*

COMPLETED Restoration Project	Project extent
Lancaster Road side-channel - 2011	640 linear feet of side-channel and 2 acres of floodplain habitat
Side-channel at Honolulu Bar - 2012	Improvement of existing side-channel to reduce stranding risk
Floodplain at Honolulu Bar - 2012	2.4 acres
Buttonbush - 2017	4.4 acres of side-channel and floodplain habitat and 2,400 linear feet of side-channel habitat.
Rodden Road - 2018	4.9 acres of habitat

c) *Potential gravel and habitat restoration projects.*

POTENTIAL Project	Project extent
Two Mile Bar	Anticipated gravel: 6,000 cubic yards. Anticipated habitat: TBD
Kerr Park Restoration	Anticipated gravel and habitat: TBD
Migratory Corridor Rehabilitation	Anticipated gravel and habitat: TBD
Goodwin Canyon	Anticipated gravel: TBD

Source: Table 2-3 of the WY 2018 Stanislaus Operations Group Annual Report (National Marine Fisheries Service 2018g).

In summary, in the 10-year period from 2009 through 2018, an average annual placement of 3,225 tons[23] was achieved, and a total of 13.8 acres and 3,040 linear feet of floodplain and side channel habitat was restored. Reclamation has been working to remove impediments to gravel augmentation in Goodwin Canyon (the easiest and least expensive option), however, restoration at the scale proposed will require partnerships with private landowners as well as funding, contracting, and permitting processes. Because it is not clear what assumptions Reclamation has made to conclude that restoration of 50 acres (over 3 times the restored acreage achieved in the past 10 years) is achievable by 2030, NMFS considers the full 50-acre target at a framework-level, with site-specific coverage within the limits identified below.

In this consultation, NMFS assumes that:

- Reclamation can achieve, on average, 4,500 tons/year of gravel augmentation. If annual targets are not achieved in some years, NMFS assumes that Reclamation will make additional catch-up contributions in other years to meet the 4,500 tons/year average by 2030. Exemptions from take prohibitions are included under the Central Valley Restoration Programmatic Opinion, for any project that meets the guidelines; projects outside those guidelines need separate ESA consultation.
- Reclamation will restore up to 50 acres of rearing habitat by 2030. NMFS considers the effects of the full 50-acre target at a framework-level. Exemptions from take prohibitions are included under the Central Valley Restoration Programmatic Opinion, for any project that meets the guidelines; projects outside those guidelines need separate ESA consultation.

Habitat restoration activities would directly benefit CCV steelhead by increasing the quantity and quality of spawning habitat, creating side channel and floodplain rearing habitat, and increasing the quality and quantity of off-channel rearing habitat in the Stanislaus River. Habitat restoration activities within the Stanislaus River would yield benefits to CCV steelhead adults and juveniles by increasing existing riparian vegetation, providing instream and overhanging object cover, new shaded riverine habitat, and additional area for food production, and would also increase the aquatic habitat complexity and diversity within the Stanislaus River and provide additional predator escape cover. Additionally, the created side channel and floodplain habitat would provide additional refuge for outmigrating juvenile CCV steelhead. These habitat benefits are expected to result in increased growth, fitness, and survival.

Construction activities associated with spawning and rearing habitat restoration projects under this proposed action component are not expected to result in any direct effects to CCV steelhead adults, eggs or emerging fry, based on timing of in-water construction (July 15 through October 15[24]), typical seasonal occurrence of these life stages in the Stanislaus River (December through June), and implementation of general avoidance and minimization measures. Construction activities associated with spawning and rearing habitat construction could result in minor, short-term, impacts to juvenile CCV steelhead (disruption to behavior, temporary displacement, increased turbidity) for restoration projects upstream of Orange Blossom Bridge, since juvenile

[23] The total gravel volume from the projects listed in **Error! Reference source not found.** is 21,500 cubic yards. Assuming a c onversion of 1.5 tons/cy, the total is 32,250 tons over the 10-year period which represents an annual placement rate of 3,225 tons per year.

[24] While not specified in the proposed action, July 15 through October 15 is the window evaluated in the effects analysis of the ROC on LTO biological assessment.

CCV steelhead are present year-round in that area. Although not specified in the ROC on LTO biological assessment, we assume standard avoidance and minimization measures typical for restoration work would be implemented, and therefore expect impacts limited to short-term behavioral changes not affecting fitness or survival.

Habitat restoration would result in an overall benefit to the CCV steelhead in the Stanislaus River by increasing habitat diversity and complexity within 50 acres for rearing juveniles, and increasing the quality and quantity of spawning gravels for adults.

8.7.1.7.2 Temperature Management Study

Reclamation proposes that it "will study approaches to improving temperature for listed species on the lower Stanislaus River, to include evaluating the utility of conducting temperature measurements/profiles in New Melones Reservoir." NMFS supports this commitment and urges Reclamation to consider developing a simple temperature forecasting tool that could be used by the Stanislaus Watershed Team to screen alternate flow schedules when shaping seasonal flows.

The study itself will not affect CCV steelhead in the Stanislaus River. The study may improve management of temperatures and flows in the future, and help to inform decisions of the Stanislaus Watershed Team.

8.7.1.8 CV Spring-run Chinook Salmon Exposure, Response, and Risk

Temporal occurrence of any CV spring-run Chinook salmon that may be in the Stanislaus River is not well understood, though anecdotal information about observations of phenotypically spring-running fish, adults holding over the summer, and early fry have been reported (Kennedy 2008; Kennedy and Cannon 2005; Kennedy and Cannon 2002). Based on adult and juvenile migration timing, egg incubation to fry emergence are assumed to occur from August through February, 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 any phenotypically spring-running Chinook salmon life stages that may be in the Stanislaus River would experience similar exposure as CCV steelhead, with the addition of over-summering adults being exposed to a greater degree to high water temperatures. Based on observations and seasonal timing, most juvenile Chinook salmon outmigrate from the Stanislaus River during periods when dissolved oxygen levels are suitable, and only a small number may be negatively affected by low dissolved oxygen as a result of the change in the complaince point. Habitat restoration actions benefitting CCV steelhead would also be expected to benefit any Chinook salmon present.

While there have been observations of phenotypic spring-run fish in the Stanislaus River in the last decade (Franks 2014), we do not have enough information to determine whether they are part of the listed CV spring-run Chinook salmon ESU. Therefore, NMFS does not further consider effects of the proposed action on these fish within the Stanislaus River in the jeopardy analysis for this species.

8.7.2 San Joaquin River

NMFS deconstructed the proposed action to identify the project components that would create stressors that may affect listed species (Table 122). The exposure, risk, and response of each species to the project-related stressors are then analyzed in the following sections for each proposed action component.

Table 122. Stressors created by components of the proposed action in the San Joaquin River.

Project Component	Water Temperature	Water Flow
Proposed Action Conditions	X	X
Conservation Measures – Lower San Joaquin River Habitat	-	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 this reach of the San Joaquin River is in the statutory Delta Division, there are several reasons to consider it separately from the Delta 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 operations. Second, this reach of the San Joaquin River is primarily riverine, while further in the Delta the San Joaquin River is primarily tidal. The proposed action components being consulted on (Table 122) do not include any operational components that originate within this reach; conditions in the reach under the proposed action are primarily affected by (1) San Joaquin River flow from upstream of the confluence with the Stanislaus River (the boundary of the action area), (2) flow entering the San Joaquin River from the Stanislaus River as a results of East Side Division operations (described in detail in Section 2.5.6), including assumptions made in the ROC on LTO biological assessment about the flow requirement at Vernalis (a compliance location within this reach) per the Bay Delta Water Quality Control Plan that can affect East Side Division operations, and (3) accretions and depletions within the reach. NMFS evaluates the effects of East Side Division operations in this reach of the San Joaquin River, in combination with the baseline boundary flows, accretions and depletions. The proposed action components being consulted on do include a conservation measure for Lower San Joaquin River Rearing Habitat.

The analysis of effects to species in the San Joaquin River focuses on effects to particular life history stages of CCV steelhead and sDPS green sturgeon.

8.7.2.1 Proposed Action Conditions

Effects of East Side Division operations in this reach of the San Joaquin River under the proposed action are compared to current operation flows below. See Section 8.7.1 for a detailed discussion of how East Side Division operations on the Stanislaus River affect the flows entering the San Joaquin River. Table 123 shows average monthly modeled flows at Vernalis in the proposed action and current operating scenario scenarios. Interpretation of year type differences from these tables is complicated by the fact that both proposed action and current operating scenario flows are summarized by the 60-20-20 year type, even though current operating scenario flows on the Stanislaus River are modeled based on the New Melones index year type.

Table 123. Exceedance table of average modeled monthly flow in the San Joaquin River at Vernalis for the proposed action scenario and current operating scenario scenario.

Current Operations 011319

Statistic	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
	Monthly Flow (CFS)											
Probability of Exceedance												
10%	3,499	2,953	4,804	11,236	14,693	15,582	14,771	14,178	9,432	5,890	2,796	3,060
20%	3,162	2,777	2,857	4,812	10,133	10,196	10,640	8,319	4,695	2,634	2,595	2,655
30%	2,980	2,527	2,401	3,611	6,119	8,499	8,616	5,538	3,364	1,990	1,909	2,491
40%	2,796	2,395	2,216	2,629	4,232	5,570	7,564	4,615	2,947	1,741	1,672	2,125
50%	2,602	2,219	2,101	2,402	3,420	3,847	6,019	3,929	2,244	1,493	1,492	1,932
60%	2,401	2,169	2,046	2,293	2,684	3,459	4,835	3,064	1,864	1,370	1,408	1,837
70%	2,247	2,059	1,979	2,114	2,305	2,906	3,778	2,705	1,449	1,163	1,310	1,741
80%	1,995	1,951	1,829	1,883	2,151	2,371	2,792	2,167	1,298	1,099	1,207	1,613
90%	1,849	1,763	1,669	1,699	1,947	2,205	1,888	1,680	1,091	891	1,068	1,477
Long Term												
Full Simulation Period[a]	2,672	2,613	3,393	5,079	6,664	7,282	7,522	6,066	4,211	2,630	1,850	2,225
Water Year Types[b,c]												
Wet (23%)	3,611	4,025	6,134	11,463	15,794	16,880	15,399	14,703	11,398	6,693	3,136	3,417
Above Normal (24%)	2,947	2,582	2,953	4,898	6,903	7,536	8,537	5,295	3,282	1,996	1,979	2,347
Below Normal (10%)	2,518	2,133	2,067	3,520	3,651	4,149	6,338	4,142	2,077	1,466	1,448	1,838
Dry (16%)	2,289	2,153	3,123	2,402	2,549	3,241	3,998	2,808	1,685	1,260	1,351	1,778
Critical (27%)	1,864	1,849	2,077	1,878	2,091	2,288	2,310	1,932	1,119	932	1,064	1,489

Proposed Action 011519

Statistic	Monthly Flow (CFS)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Probability of Exceedance												
10%	3,500	2,975	4,804	12,398	17,192	15,482	15,015	15,004	9,433	5,780	2,744	3,060
20%	3,148	2,778	2,904	4,838	10,122	10,324	10,641	8,327	4,781	2,503	2,602	2,635
30%	2,996	2,483	2,321	3,613	6,806	8,470	8,960	5,767	2,704	1,957	1,894	2,486
40%	2,835	2,395	2,204	2,681	4,232	5,306	7,921	4,655	2,370	1,730	1,679	2,128
50%	2,628	2,219	2,101	2,371	3,071	3,847	6,437	4,131	2,069	1,507	1,497	1,933
60%	2,402	2,170	2,046	2,290	2,614	3,440	4,786	2,910	1,757	1,362	1,407	1,830
70%	2,137	2,060	1,979	2,084	2,305	2,906	3,212	2,305	1,351	1,153	1,319	1,743
80%	1,978	1,951	1,829	1,883	2,128	2,372	2,500	1,866	1,217	994	1,136	1,575
90%	1,807	1,763	1,669	1,699	1,891	2,205	1,765	1,473	978	874	1,029	1,452
Long Term												
Full Simulation Period[a]	2,669	2,607	3,368	5,109	6,792	7,290	7,513	5,982	4,102	2,619	1,831	2,214
Water Year Types[b,c]												
Wet (23%)	3,607	4,001	6,006	11,466	16,343	17,052	15,339	14,678	11,759	6,815	3,125	3,417
Above Normal (24%)	2,994	2,579	2,964	4,928	6,922	7,468	8,887	5,409	2,691	1,915	1,976	2,340
Below Normal (10%)	2,542	2,133	2,067	3,784	3,834	4,032	6,497	4,189	1,974	1,473	1,454	1,836
Dry (16%)	2,239	2,153	3,132	2,393	2,464	3,241	3,795	2,537	1,570	1,245	1,349	1,776
Critical (27%)	1,829	1,849	2,077	1,871	2,058	2,274	2,071	1,680	1,040	864	1,003	1,457

Proposed Action 011519 minus Current Operations 011319

	Monthly Flow (CFS)											
Statistic	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Probability of Exceedance												
10%	1	22	0	1,162	2,499	-100	245	826	1	-111	-52	0

20%	**-14**	0	47	26	**-11**	128	1	7	87	**-131**	7	**-20**
30%	16	**-45**	**-79**	3	687	**-29**	344	229	**-660**	**-33**	**-15**	**-5**
40%	39	0	**-11**	52	0	**-264**	357	39	**-577**	**-11**	7	3
50%	26	0	0	**-30**	**-349**	0	419	202	**-175**	14	5	1
60%	1	0	0	**-3**	**-70**	**-19**	**-48**	**-154**	**-107**	**-9**	**-1**	**-8**
70%	**-111**	1	0	**-30**	0	0	**-566**	**-400**	**-98**	**-10**	9	2
80%	**-17**	1	0	**-1**	**-23**	0	**-292**	**-301**	**-81**	**-105**	**-71**	**-38**
90%	**-42**	0	0	0	**-56**	**0**	**-123**	**-208**	**-113**	**-17**	**-39**	**-25**
Long Term												
Full Simulation Period[a]	**-4**	**-6**	**-26**	31	127	8	**-10**	**-84**	**-110**	**-11**	**-20**	**-11**
Water Year Types[b,c]												
Wet (23%)	**-4**	**-24**	**-128**	3	550	171	**-61**	**-25**	362	122	**-11**	0
Above Normal (24%)	47	**-3**	11	31	19	**-68**	349	114	**-591**	**-80**	**-4**	**-6**
Below Normal (10%)	23	0	0	264	183	**-117**	159	47	**-103**	7	6	**-2**
Dry (16%)	**-50**	0	9	**-9**	**-85**	1	**-203**	**-271**	**-114**	**-15**	**-1**	**-2**
Critical (27%)	**-36**	0	0	**-7**	**-33**	**-15**	**-239**	**-253**	**-80**	**-68**	**-61**	**-32**

a Based on the 82-year simulation period.
b As defined by the San Joaquin Valley 60-20-20 Index Water Year Hydrologic Classification (State Water Resources Control Board 1999).
c These results are displayed with calendar year - year type sorting.
d All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.
e These are draft results meant for qualitative analysis and are subject to revision.

Source: Table 39b-3 from Appendix D, Attachment 3-2, of the ROC on LTO biological assessment

The largest reductions in flow in the proposed action relative to the current operating scenario occur in April to June, likely related to some combination of changes in the assumed Vernalis requirements and the stepped release plan. In a Critical year, for example, the average 239 cfs decrease in April flows in the proposed action represents a ten percent decrease from the average April current operating scenario flows of 2,310 cfs; the average 253 cfs decrease in May flows in the proposed action represents a 13 percent decrease from the average May current operating scenario flows of 1,932 cfs; the average 80 cfs decrease in June flows in the proposed action represents a seven percent decrease from the average June current operating scenario flows of 1,119 cfs.

Higher flows tend to result in cooler water temperatures at Vernalis. Water temperatures are also highly affected by air temperature (Figure 131). Higher flows and cooler temperatures typically extend into summer in wetter years.

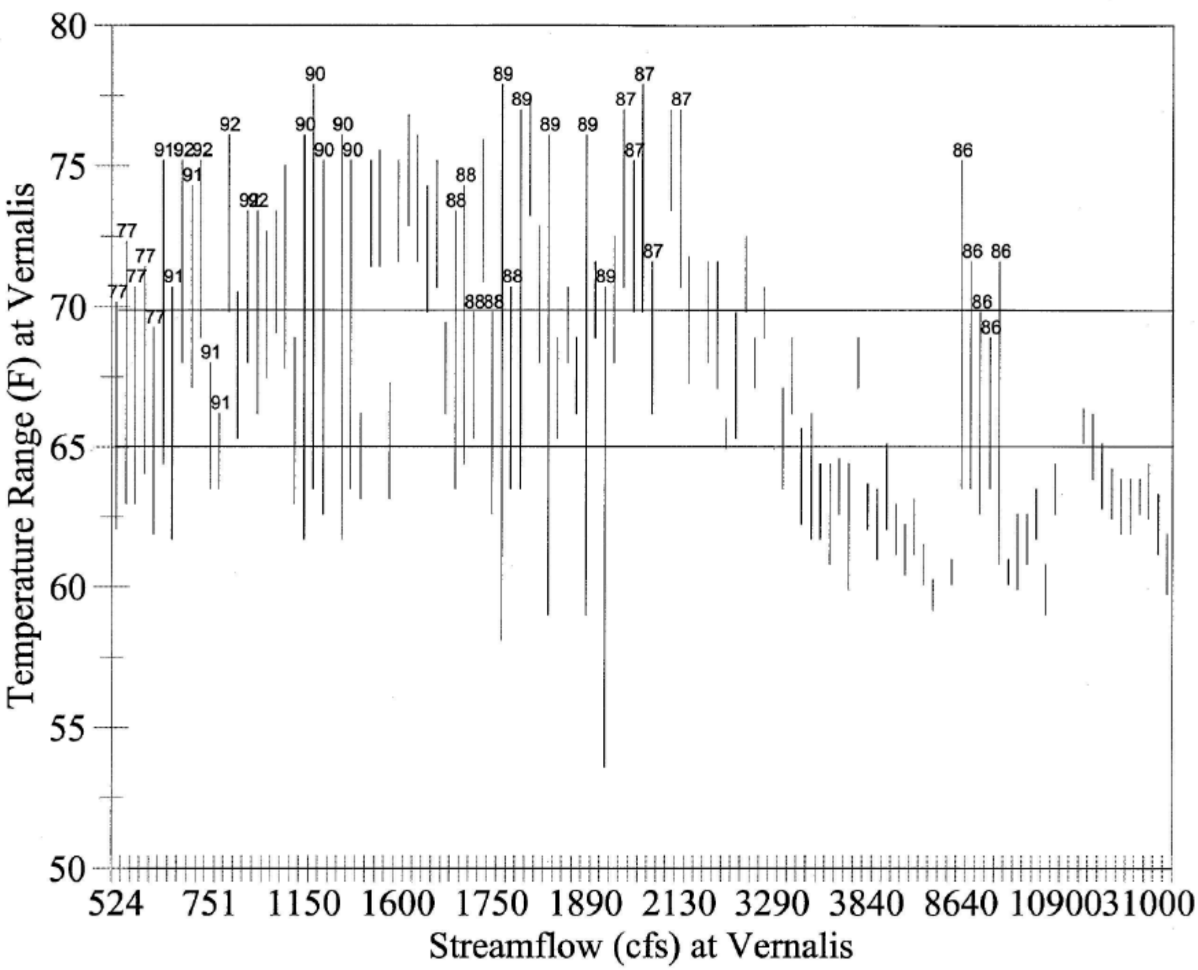


Figure 131. Range in daily water temperature relative to streamflow in the San Joaquin River at Vernalis from the period of May 13 to 17 in 1962, 1963, 1970, and 1973 to 1994.

Source: Figure 11 from Mesick (2001)

Monthly average water temperatures at Vernalis by month and San Joaquin ("60-20-20") year type are provided in Table 124. to show the range of temperatures expected under the proposed action and current operating scenario.

Table 124. Monthly average water temperatures at Vernalis by month and San Joaquin ("60-20-20") year type for proposed action and current operating scenario scenarios.

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Vernalis water temperatures under PA												
Wet	62.4	55.9	49.5	48.6	51.9	55.5	59.3	64.8	68.0	72.0	73.8	70.4
Above Normal	63.1	55.4	48.9	48.7	52.7	56.9	59.3	65.4	73.3	77.4	76.0	72.4
Below Normal	62.1	55.6	48.6	49.1	53.2	58.5	60.1	64.0	73.3	78.2	76.4	72.8
Dry	63.4	56.1	48.6	48.3	53.8	58.5	63.7	68.1	75.3	78.4	76.5	73.1
Critical	65.3	56.9	49.3	48.6	54.8	61.1	65.4	69.9	75.5	78.8	77.6	73.7
Dry & Critical	64.7	56.6	49.1	48.5	54.5	60.3	64.9	69.4	75.4	78.7	77.3	73.6
Vernalis water temperatures under COS												
Wet	62.4	55.9	49.5	48.6	52.0	55.6	59.3	64.8	68.3	72.2	73.8	70.4
Above Normal	63.2	55.4	48.9	48.7	52.7	56.9	59.6	65.7	70.4	76.6	75.8	72.3
Below Normal	62.2	55.7	48.6	49.1	53.1	58.4	60.3	64.2	72.2	78.1	76.4	72.8
Dry	63.4	56.1	48.7	48.4	53.8	58.5	63.0	66.8	74.8	78.3	76.5	73.1
Critical	65.5	56.9	49.3	48.6	54.8	61.1	64.6	68.7	74.9	78.3	77.1	73.6
Dry & Critical	64.9	56.7	49.1	48.5	54.5	60.3	64.1	68.1	74.9	78.3	76.9	73.4

8.7.2.2 CCV Steelhead Exposure, Response, and Risk

8.7.2.2.1 CCV Steelhead Exposure

Life history timing of CCV steelhead adults and juveniles in the mainstem San Joaquin River is described in Section 6.5. Additionally, CCV steelhead may exit the Stanislaus River 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 unsuitable for juvenile CCV steelhead in the summer and fall, so juveniles would not be expected to be present in those seasons.

8.7.2.2.2 CCV Steelhead Response

Expected effects from the proposed action conditions in the lower San Joaquin River will expose CCV steelhead to limited rearing habitats and potential migrational delays, leading to increased vulnerability to factors including poor water quality, which reduce survival, including predation.. This effects analysis identifies and describes the most important project-related stressors to these species.

Many of the flow-related stressors affecting CCV steelhead in this reach of the San Joaquin River identified in Table 122 above are similar to those discussed for CCV steelhead in the Stanislaus River in Section 8.7.1.5.1.2. Water temperatures, however, are separately evaluated below since water temperatures are higher on the San Joaquin River than the Stanislaus River.

Suitable temperatures for each CCV steelhead life stage (with life-stage timing noted) are summarized in Table 120 and the evaluation of monthly average water temperatures at Vernalis under the proposed action using these criteria is summarized in. Because the modeled monthly temperatures are lower than the maximum daily temperatures most relevant for evaluating 7DADM criteria, this analysis underestimates temperature-related impacts to CCV steelhead on the San Joaquin River.

Because the modeled monthly temperatures, averaged by water year type, will be lower than the maximum daily temperatures most relevant for evaluating 7DADM criteria, this analysis underestimates temperature-related impacts to CCV steelhead on the Stanislaus River. Red shading indicates month/year type combinations in which monthly water temperatures exceed the temperature criterion. Gray shading indicates month/year type combinations in which the lifestage is not expected to be present in the San Joaquin River.

Table 125. Salmonid temperature requireemnts by life stage and timing of California Central Valley steelhead residence in the San Joaquin River.

Life Stage & Timing	Temperature Criterion
Salmon/trout juvenile rearing (December - May)	61°F 7DADM
Salmon/trout migration plus non-core juvenile rearing *(Combined:* year-round) *Adult migration:* July-March *Juvenile migration:* February-June *Non-core juvenile rearing:* December –May	64°F 7DADM
Salmon/trout migration *(Combined:* year-round) *Adult migration:* year-round *Juvenile migration:* February-June	68°F 7DADM

Source: U.S. EPA's Guidance for Pacific Northwest State and Tribal Temperature Water Quality Standards (U.S. Environmental Protection Agency 2003)

Table 126. Modeled water temperature suitability under the proposed action (panel a) and current operating scenario (panel b) for California Central Valley steelhead by lifestages.

a) proposed action scenario

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Juvenile rearing (61°F 7DADM) -- December - May												
Wet	62.4	55.9	49.5	48.6	51.9	55.5	59.3	64.8	68.0	72.0	73.8	70.4
Above Normal	63.1	55.4	48.9	48.7	52.7	56.9	59.3	65.4	73.3	77.4	76.0	72.4
Below Normal	62.1	55.6	48.6	49.1	53.2	58.5	60.1	64.0	73.3	78.2	76.4	72.8
Dry	63.4	56.1	48.6	48.3	53.8	58.5	63.7	68.1	75.3	78.4	76.5	73.1
Critical	65.3	56.9	49.3	48.6	54.8	61.1	65.4	69.9	75.5	78.8	77.6	73.7
Migration plus non-core juvenile rearing (64°F 7DADM) -- Year-round												
Wet	62.4	55.9	49.5	48.6	51.9	55.5	59.3	64.8	68.0	72.0	73.8	70.4
Above Normal	63.1	55.4	48.9	48.7	52.7	56.9	59.3	65.4	73.3	77.4	76.0	72.4
Below Normal	62.1	55.6	48.6	49.1	53.2	58.5	60.1	64.0	73.3	78.2	76.4	72.8
Dry	63.4	56.1	48.6	48.3	53.8	58.5	63.7	68.1	75.3	78.4	76.5	73.1
Critical	65.3	56.9	49.3	48.6	54.8	61.1	65.4	69.9	75.5	78.8	77.6	73.7
Migration plus non-core juvenile rearing (68°F 7DADM) -- Year-round												
Wet	62.4	55.9	49.5	48.6	51.9	55.5	59.3	64.8	68.0	72.0	73.8	70.4
Above Normal	63.1	55.4	48.9	48.7	52.7	56.9	59.3	65.4	73.3	77.4	76.0	72.4
Below Normal	62.1	55.6	48.6	49.1	53.2	58.5	60.1	64.0	73.3	78.2	76.4	72.8
Dry	63.4	56.1	48.6	48.3	53.8	58.5	63.7	68.1	75.3	78.4	76.5	73.1
Critical	65.3	56.9	49.3	48.6	54.8	61.1	65.4	69.9	75.5	78.8	77.6	73.7

b) current operating scenario

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Juvenile rearing (61°F 7DADM) -- December - May												
Wet	62.4	55.9	49.5	48.6	52.0	55.6	59.3	64.8	68.3	72.2	73.8	70.4
Above Normal	63.2	55.4	48.9	48.7	52.7	56.9	59.6	65.7	70.4	76.6	75.8	72.3
Below Normal	62.2	55.7	48.6	49.1	53.1	58.4	60.3	64.2	72.2	78.1	76.4	72.8
Dry	63.4	56.1	48.7	48.4	53.8	58.5	63.0	66.8	74.8	78.3	76.5	73.1
Critical	65.5	56.9	49.3	48.6	54.8	61.1	64.6	68.7	74.9	78.3	77.1	73.6
Migration plus non-core juvenile rearing (64°F 7DADM) -- Year-round												
Wet	62.4	55.9	49.5	48.6	52.0	55.6	59.3	64.8	68.3	72.2	73.8	70.4
Above Normal	63.2	55.4	48.9	48.7	52.7	56.9	59.6	65.7	70.4	76.6	75.8	72.3
Below Normal	62.2	55.7	48.6	49.1	53.1	58.4	60.3	64.2	72.2	78.1	76.4	72.8
Dry	63.4	56.1	48.7	48.4	53.8	58.5	63.0	66.8	74.8	78.3	76.5	73.1
Critical	65.5	56.9	49.3	48.6	54.8	61.1	64.6	68.7	74.9	78.3	77.1	73.6
Migration plus non-core juvenile rearing (68°F 7DADM) -- Year-round												
Wet	62.4	55.9	49.5	48.6	52.0	55.6	59.3	64.8	68.3	72.2	73.8	70.4
Above Normal	63.2	55.4	48.9	48.7	52.7	56.9	59.6	65.7	70.4	76.6	75.8	72.3
Below Normal	62.2	55.7	48.6	49.1	53.1	58.4	60.3	64.2	72.2	78.1	76.4	72.8
Dry	63.4	56.1	48.7	48.4	53.8	58.5	63.0	66.8	74.8	78.3	76.5	73.1
Critical	65.5	56.9	49.3	48.6	54.8	61.1	64.6	68.7	74.9	78.3	77.1	73.6

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 outmigrating CCV steelhead, or even serve as a barrier to migration, in May through September. 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.

8.7.2.2.3 CCV Steelhead Risk

Based on the effects to CCV steelhead associated with the proposed action conditions described above, fitness consequences to individuals include reduced survival and growth during juvenile rearing, and reduced survival and growth during juvenile outmigration in the lower San Joaquin River. Additionally, conditions may restrict the window of successful outmigration of individuals and, thus, reduce the diversity of outmigration timing through the lower San Joaquin River for all the San Joaquin River steelhead populations.

8.7.2.3 sDPS Green Sturgeon Exposure, Response, and Risk

Catch of sDPS green sturgeon in the San Joaquin River on Sturgeon Fishing Report Cards[25] and the verified observation of an sDPS green sturgeon on the Stanislaus River (Anderson et al. 2018) indicate opportunistic use of the San Joaquin River basin when conditions are favorable (Table 127). No spawning on the San Joaquin River has been verified.

Table 127. Summary of green sturgeon catch and length statistics from Sturgeon Fishing Report Cards for observations in the San Joaquin River from Stockton to the Highway 140 Bridge.

Report Card Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total
Number of Anglers	-	8	13	-	-	-	-	2	-	-	1	**24**
Winter Catch	-	1	4	-	-	-	-	1	-	-	-	**6**
Spring Catch	-	7	10	-	-	-	-	-	-	-	1	**18**
Summer Catch	-	0	-	-	-	-	-	-	-	-	-	**0**
Fall Catch	-	1	2	-	-	-	-	1	-	-	1	**5**
Total Catch	**-**	**9**	**16**	**-**	**-**	**-**	**-**	**2**	**-**	**-**	**2**	**29**
Number Measured	-	9	16	-	-	-	-	-	-	-	-	**25**
Minimum Length (inches)	-	49.0	47.0	-	-	-	-	-	-	-	-	
Maximum Length (inches)	-	66.0	62.0	-	-	-	-	-	-	-	-	
Average Length (inches)	-	58.1	54.3	-	-	-	-	-	-	-	-	

Data sources: California Department of Fish and Game (2008); California Department of Fish and Game (2009); California Department of Fish and Game (2010a); California Department of Fish and Game (2011); California Department of Fish and Game (2012); California Department of Fish and Wildlife (2013a); California Department of Fish and Wildlife (2014a); California Department of Fish and Wildlife (2015a); California Department of Fish and Wildlife (2016a); California Department of Fish and Wildlife (2017a); DuBois and Danos (2018); Gleason et al. (2008)

[25] Available at the California Department of Fish and Wildlife Bay Delta Region sturgeon data bibliography page.

SDPS green sturgeon presence and behavior in the San Joaquin River is poorly understood and use of this reach of the San Joaquin River is likely opportunistic. Mechanisms and probable change in fitness would generally be similar to those discussed in the Sacramento Division flow and temperature analyses for juvenile green sturgeon. As described above, flows are primarily expected to be lower under the proposed action in April through June compared to current conditions. 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 by sDPS green sturgeon juveniles would overlap with the most pronounced effects of the proposed action. Some individuals may be exposed to reductions in flows, and related increases in temperature and decreases in suitable rearing habitat, that would cause small reductions in the survival or growth of a small number of individuals.

Salmonids in the San Joaquin River basin were once abundant and widely distributed, but currently face numerous limiting factors. The NMFS Central Valley Recovery Plan identified that 'Very High' stressors for juvenile CCV steelhead outmigration on the San Joaquin River include habitat availability, changes in hydrology, water temperature, reverse water flow, contaminants, habitat degradation, and entrainment (National Marine Fisheries Service 2014b). The impacts of these stressors can be studied using acoustic telemetry, and an updated conceptual model, developed by the South Delta Salmonid Research Collaborative (SDSRC) demonstrates how experimental variables of interest to the 6-Year Study (i.e. Delta water operations, tributary water operations, and habitat) are influential in survival and behavior of emigrating smolts. This conceptual model has guided specific hypotheses and investigations of the 6-Year Study.

Reclamation conducted a 6-year steelhead telemetry study on the Stanislaus River (2011-2016) and is proposing to continue an acoustic tagging study on the San Joaquin River to determine entrainment of San Joaquin River origin CCV steelhead into the Tracy and Jones Pumping Plants. The Stanislaus River Research and Monitoring Program is the most comprehensive and longest running salmon and steelhead monitoring programs in California's San Joaquin Basin, although data are not publicly available. Initiated by FISHBIO personnel in 1993 for the Oakdale and South San Joaquin irrigation districts and Tri-Dam Project, the program's suite of ongoing monitoring activities tracks the abundance, distribution, migration characteristics, and habitat use of salmon and steelhead.

8.7.2.3.1 Deconstruct the Action - San Joaquin Basin Steelhead Telemetry Study

Reclamation proposes to continue the 6-year steelhead telemetry study for the migration and survival of San Joaquin origin CCV steelhead. The proposed action component incorporates information from the Salmonid Scoping Team and the 6-year steelhead telemetry study to update protections for San Joaquin origin CCV steelhead, continuing the telemetry studies to further refine measures for protecting CCV steelhead. Details of the environmental parameters to be manipulated during the proposed study have not been provided. NMFS assumes that they will be determined during the study development and that the study will be designed to fit within the proposed operations.

NMFS assumes that hatchery steelhead would be used for the San Joaquin steelhead telemetry study under the proposed action, which was not specified in the description for this proposed action component. Reclamation proposes to insert acoustic tags into juvenile (assumed to be hatchery) steelhead to track them as they move through the south Delta. Acoustic arrays would monitor their presence. This study would help fill a gap in knowledge related to the survival of CCV steelhead originating in the San Joaquin River basin. If Reclamation uses hatchery juvenile steelhead for its acoustic telemetry study and export operations do not differ from the proposed proposed action, this study will be covered for incidental take under this consultation.

However, the details of the acoustic telemetry study were not provided in the proposed action description. If natural origin CCV steelhead are proposed to be used for the study fish, or if operations of the exports differ from what has been proposed for the proposed action, then this proposed action component will be considered as a programmatic consultation.

8.7.2.3.2 Assess Species Exposure and Response to the San Joaquin Basin Steelhead Telemetry Study

Natural origin CCV steelhead and fish species may be affected by hatchery releases, as they would compete for food resources and rearing habitat. However, it is expected that the number of tagged fish would be low compared to the number of natural origin fish present in the system. Furthermore, the overall survival of tagged fish returning from the ocean as adults to spawn is considered to be very low, thus minimizing the effects of hatchery steelhead straying into the system as a result of the study implementation. The specifics of the proposed telemetry study, including the number of acoustic tagged fish and release timing were not provided in the ROC on LTO biological assessment.

8.7.2.3.3 Risk to CCV steelhead

NMFS assumes that attributes of the proposed 6-year study would be similar to the previous study, including sample size, source of tagged hatchery fish, tagging methods, transport, and release timing. The continuation of the steelhead telemetry study will provide important information about the response of fish migration to flows, exports, and other stressors in the San Joaquin River corridor. NMFS also assumes that the study would continue to assess the relationship of exports to flow, route selection at channel bifurcations in the South Delta and mainstem San Joaquin River, survival in the different channels reaches of the South Delta, and ultimately, survival through the Delta to Chipps Island as a whole.

An important aspect of the analysis for CCV steelhead concerns the status of the Southern Sierra Nevada Diversity Group, which is critical to preserving spatial structure of the CCV steelhead DPS. This diversity group, consisting of extant populations in the Calaveras, Stanislaus, Tuolumne, Merced and upper mainstem San Joaquin rivers, is very unstable due to the poor status of each population. This status is due to both project-related and non-project related stressors.

8.7.2.4 Conservation Measures

Reclamation included two conservation measures as part of its proposed action to support CCV steelhead in the American River. These measures are assessed in this section.

8.7.2.4.1 Lower San Joaquin River Habitat

The ROC on LTO biological assessment describes the "Lower SJR Rearing Habitat" conservation measure as "Reclamation may work with private landowners to create a bottom-up, locally driven regional partnership to define and implement a large-scale floodplain habitat restoration effort in the Lower San Joaquin River. Such a large scale effort along this corridor would require significant support from a variety of stakeholders, which could be facilitated through a regional partnership." NMFS supports both regional partnerships and multi-benefit floodplain habitat restoration projects in the San Joaquin basin and expects that such a project would provide benefits to CCV steelhead and could provide benefits to juvenile sDPS green sturgeon[26]. Acknowledging that the full scope of the effort is outside Reclamation and DWR's discretion and would require regional partners, in this Opinion, NMFS considers the benefits of this proposed conservation measure at the framework level.

San Joaquin River Scour Hole

Reclamation and DWR propose to plan and implement measures to reduce the predation intensity at the San Joaquin River Scour Hole through modifications to the channel geometry and associated habitats. This is expected to increase juvenile survival for individuals in this area compared to current conditions.

San Joaquin Basin Steelhead Collaborative

Reclamation proposes to coordinate with CSAMP to sponsor a workshop for developing a plan to monitor steelhead populations within the San Joaquin Basin and/or the San Joaquin River downstream of the confluence of the Stanislaus River, including steelhead and rainbow trout on non-project San Joaquin tributaries. Information from this monitoring, once in place, is expected to improve flow management actions that would ultimately improve migration and survival through the San Joaquin River and South Delta, although the nature of such monitoring is not yet known, and we do not have sufficient information about the proposed program to evaluate any specific effects over the duration of the proposed action.

8.7.3 Division Effects Summary

The following tables summarize the project-related stressors for each species and component of the proposed action. The 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.

[26] Green sturgeon presence and behavior in the San Joaquin River is poorly understood and floodplain rearing has not been documented. However, there are a number of benefits that floodplain habitat could provide juvenile green sturgeon such as increased growth opportunity and refuge from predators.

8.7.3.1 CCV Steelhead

The following tables summarize the project-related stressors for each species and component of the proposed action. The 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 (Table 128, Table 129, and Table 130.

Table 128. Summary of East Side Division operation-related effects on egg and fry California Central Valley steelhead.

Action Component	Stressor	Individual Response and Rationale of Effect	Severity of Stressor/Level of Benefit	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness
Seasonal operations and Stepped Release Plan	Water Temperature Water Flow	Egg mortality from lack of interstitial flow; suppressed growth rates	Sub-lethal to Lethal	Medium	High	High	Medium	Reduced survival

Table 129. Summary of East Side Division operation related effects on juvenile California Central Valley steelhead.

Action Component	Stressor	Individual Response and Rationale of Effect	Severity of Stressor/Level of Benefit	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness
Seasonal operations and Stepped Release Plan	Water Flow (March to June)	Fish do not leave reach of river before temperatures rise at lower river reaches and in Delta; thermal stress; misdirection through Delta leading to increased residence time and higher risk of predation	Sublethal and indirectly lethal via predation	Medium	High	Medium to High	Medium	Reduced survival; Reduced diversity

Action Component	Stressor	Individual Response and Rationale of Effect	Severity of Stressor/Level of Benefit	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness
Seasonal operations and Stepped Release Plan	Water Temperatures (Mar to June)	Warm water may lead to missing triggers to elect anadromous life history; failure to escape river before temperatures rise at lower river reaches and in Delta; continued thermal stress compared to current conditions	Sublethal	Medium	Low	Low	Medium	Reduced diversity
Conservation Measure	Spawning and Rearing Habitat Restoration	Increased food supply; increased growth rates; refuge from predation; larger size at time of emigration	Beneficial: High	Medium	Medium	High	High	Increased survival, increased growth
Conservation Measure	Lower San Joaquin River Habitat	Increased food supply; increased growth rates; refuge from predation; larger size at time of emigration	Beneficial: High	Medium	Medium	High	High	Increased survival, increased growth

Table 130. Summary of East Side Division operation-related effects on adult California Central Valley steelhead.

Action Component	**Stressor**	**Individual Response and Rationale of Effect**	**Severity of Stressor/Level of Benefit**	**Proportion of Population Exposed**	**Frequency of Exposure**	**Magnitude of Effect**	**Weight of Evidence**	**Probable Change in Fitness**
Seasonal operations and Stepped Release Plan	Water Flow	Reduced suitable spawning habitat; fines inundation of redds	Sublethal	Medium	High	Medium	Medium	Reduced reproductive success
Conservation Measure – Spawning and Habitat Restoration	Spawning Habitat	Increased suitable spawning habitat;	Beneficial: medium	Medium	High (Once completed, habitat will be available each year)	Medium	High	Increased reproductive success
Alteration of Stanislaus River Dissolved Oxygen Requirement - (7.0 mg/L) 31 miles upstream to Orange Blossom Bridge (OBB)	Temporary Low dissolved oxygen Barrier	Adult steelhead are primarily present upstream of OBB, however, few may be migrating through during summer months, and may be exposed to reduced dissolved oxygen..	Minor	Small	Low	Low	Medium	Low

8.7.3.2 sDPS Green Sturgeon

The reductions in spring flows, and associated temperature, water quality, water depth, and wetland function are expected to have minor sublethal impacts on adults and juveniles in the San Joaquin River between the confluence with the Stanislaus River and Mossdale. Adults and juveniles are present year round, but responses to flow and temperature-related stressors are most likely to occur during winter and spring, when the proposed action would have the most effect on flows. These stressors are expected to cause small reductions in the survival or growth of a small number of individual sDPS green sturgeon.

8.8 Effects of the Action on Southern Resident Killer Whales

The potential impact of the proposed action on SRKW is the change in availability of SRKW preferred prey, Chinook salmon, in the coastal waters where Chinook salmon from the Central Valley of California may be encountered by SRKW.

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 winter-run Chinook salmon. This is reflected in estimates of annual spawning escapement for the Sacramento and San Joaquin rivers and their associated tributaries provided by CDFW; fall-run Chinook salmon escapement estimates are 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 winter-run Chinook salmon (California Department of Fish and Wildlife 2018b).

Our approach to analyzing the effects of the proposed action on SRKW during consultation included analysis of impacts to fall-run and late fall-run Chinook salmon, in addition to impacts to ESA-listed Sacramento River winter-run and CV spring-run Chinook salmon in the Central Valley as individuals from all populations are potential prey for SRKW along the U.S. West Coast.

We did not conduct the same analysis for non-ESA-listed Chinook salmon during consultation as we did for ESA-listed species because that is not what the ESA requires. The potential impact of the proposed action on SRKW occurs through impacts to the availability of all potential Chinook prey sources from the Central Valley. We will focus on the overall impact of the proposed action on Chinook productivity from the entire system and ultimate abundance of CV Chinook salmon in the ocean that may be available as prey for SRKW using available information that characterizes 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 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 project in comparison to the current operating scenario to gauge how productivity is affected by the operational changes that have been proposed. Finally, where necessary, we consider additional qualitative assessment of stressors that cannot be captured directly through these models. See Appendix J for a detailed description of quantitative analyses referenced in this Section.

8.8.1 Project-Related Impacts on the Prey Base

To evaluate the effects of the proposed action on SRKW we examined the current trends in CV Chinook salmon abundance and the impacts of the proposed action on CV Chinook salmon popluations.

8.8.1.1 Current Trends in CV Chinook Salmon Abundance

Over the last 20 years (1998 to 2017), the total annual adult escapement of each Chinook salmon run in the Central Valley has varied considerably; especially the total annual escapement for the predominant fall-run Chinook salmon population which has ranged from just over 50,000 adults to almost 900,000 adults during that time period (Figure 132, Figure 133, Figure 134, and Figure 135). Using analysis of variance (ANOVA) linear regression, trends indicate that the average total annual adult escapement has significantly declined over the last 20 years for fall-run Chinook salmon ($F=8.54$; $\alpha=0.009$), late fall-run Chinook salmon ($F=14.3$; $\alpha=0.001$), and CV spring-run Chinook salmon ($F=4.59$; $\alpha=0.046$). The trend for winter-run Chinook salmon over this time is negative as well, but not significantly so ($F=1.99$; $\alpha=0.175$). As described in the *Status of the Species* (Section 6), ESA-listed Chinook salmon runs in the Central Valley had declined to very low abundances at the time of the last status review (National Marine Fisheries Service 2016a; National Marine Fisheries Service 2016c), although recent adult returns in 2018 and 2019 have shown higher abundances than previous years. In 2018, estimates of total escapement of late fall-run Chinook salmon remained similar to 2017 (5,205 versus 4,816 individuals, respectively), and estimated total 2018 escapement of fall-run Chinook salmon (172,099) was higher than it has been since 2014 (California Department of Fish and Wildlife 2019a).

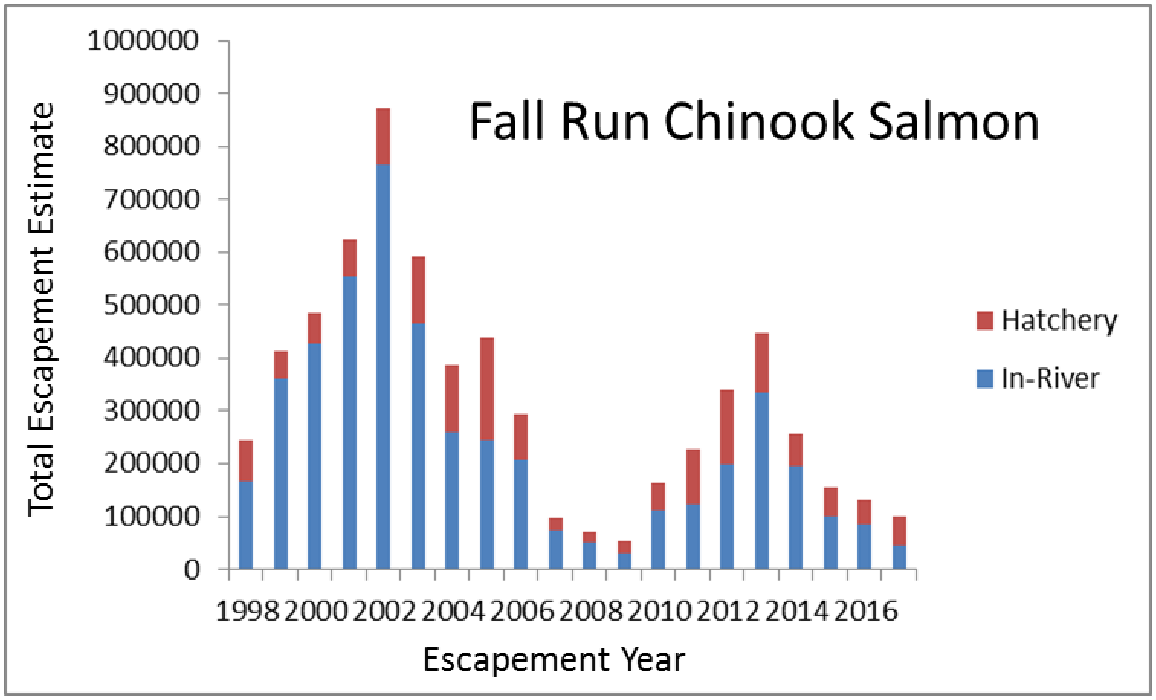


Figure 132. Annual escapement of adult fall-run Chinook salmon to river systems in the Central Valley from 1998 to 2017.

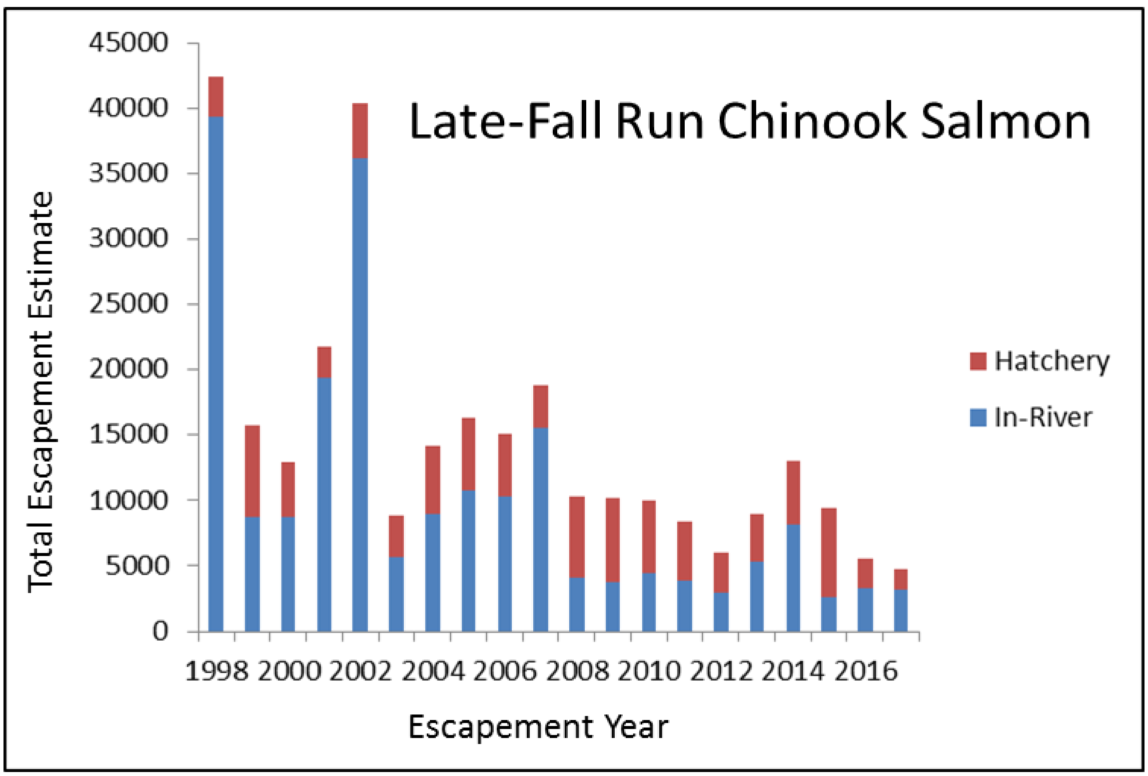


Figure 133. Annual escapement of adult late fall-run Chinook salmon to river systems in the Central Valley from 1998 to 2017.

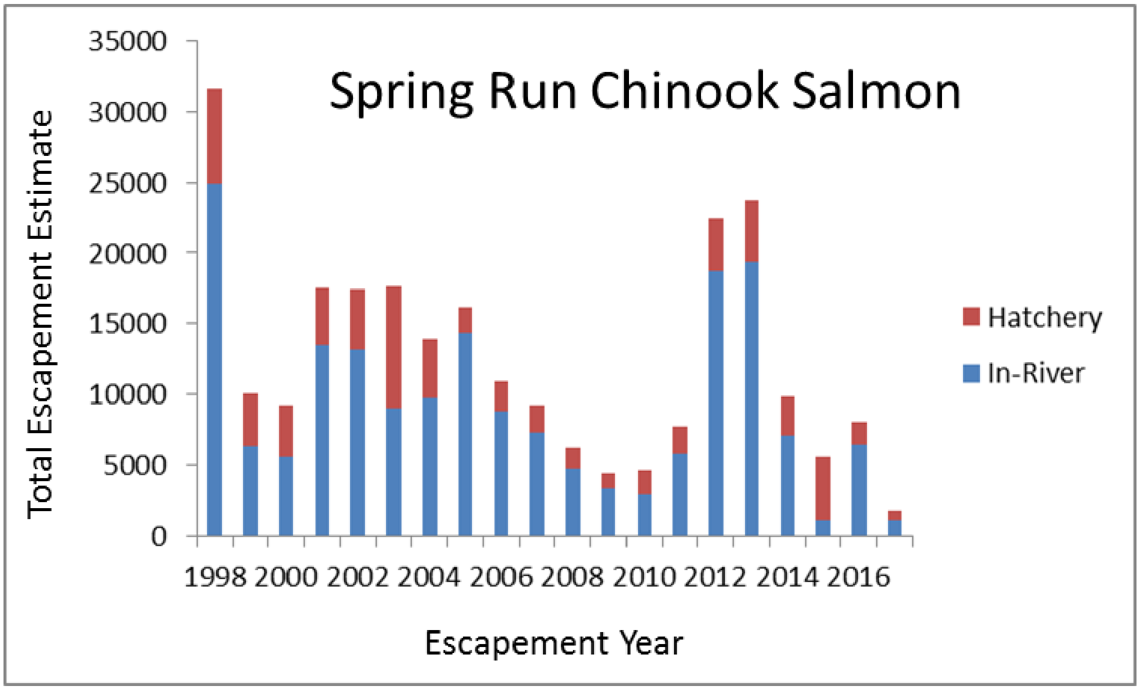


Figure 134. Annual escapement of adult spring-run Chinook salmon to river systems in the Central Valley from 1998 to 2017.

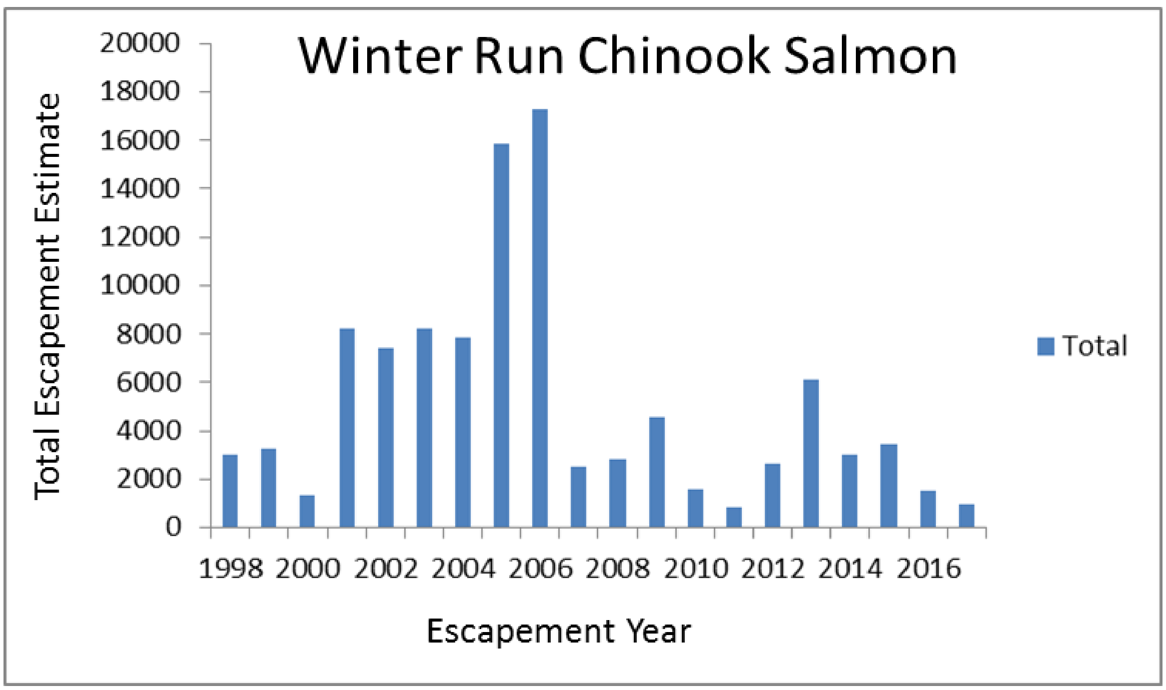


Figure 135. Annual escapement of adult winter-run Chinook salmon to river systems in the Central Valley from 1998 to 2017.

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 Section 6: *Status of the Species* and Section 7: *Environmental Baseline*). Among the major influences for all Chinook salmon in the Central Valley is the ongoing operation of the CVP and SWP.

8.8.1.2 Proposed Action Impacts to Central Valley Chinook Salmon

Based on the analyses of expected effects of the proposed action to ESA-listed CV Chinook salmon populations, reductions in the survival and productivity of all CV Chinook salmon populations (including fall-run and late fall-run Chinook salmon) are expected to occur throughout the proposed action, and the greatest effects will occur during the drier water years when effects of the proposed action are most pronounced. In particular, 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 CV Chinook salmon would be similarly impeded by warm water temperatures in the fall as described 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 as a result of proposed reductions in minimum flows in the fall and winter. Juvenile outmigration timing of fall and late fall-run Chinook salmon is similar to that of CV spring-run Chinook salmon and CCV steelhead in the Sacramento River as well, 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 SRKW in the southern portion of their coastal range.

The reduced abundance of prey could be detected by all members of K and L pod during foraging on a reduced prey field, leading to increased expenditures of energy during foraging. The exposure of members of J pod to reduced Chinook salmon abundance in coastal waters is not as clear based on the available data regarding their distributions and contaminant signatures as described in the *Status of the Species* (Section 6.9), but available information suggest their exposure may be much more limited or nonexistent. The expected consequences of biologically significant reductions in the abundance of preferred prey for these SRKW are reductions in the fitness of individuals because impaired foraging behavior and increased energy expended to find sufficient prey and nutritional stress, which can diminish health, lower growth rates, lower reproductive rates and increase mortality rates. Based on the general relative analyses that have been described, all members of K and L pod are expected to be adversely affected, or "harmed,"[27] through the increased risk of impaired foraging due to decreased Chinook salmon abundance in the ocean resulting from effects of the proposed action.

[27] As harm is defined in ESA implementing regulations 50 CFR 222.102. 2012. Definitions. Pages 283-288 *in* N. M. F. Service, editor. Office of the Federal Register, ibid.,, we associate changes in foraging behavior and increased risk of nutritional stress as causing injury to Southern Residents **"***by significantly impairing essential behavioral patterns, including, breeding, spawning, rearing, migrating, feeding or sheltering"*; specifically, in this case, feeding**.**

8.8.2 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 131 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 2007-2013 (Palmer-Zwahlen et al. 2018; Palmer-Zwahlen et al. 2019; Palmer-Zwahlen and Kormos 2015). The number of hatchery-produced fish released each year for all CV Chinook salmon runs combined during that time averaged 35,059,237; ranging from 30,455,664 to 38,510,728 (Appendix J). 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.

Table 131. Central Valley Chinook salmon hatchery release goals and proportion released in-river and in Bay areas.

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	Fall[a]	2,000,000	100 %	0
Nimbus	Fall	4,000,000	33 %	67 %
Mokelumne	Fall	5,000,000	70 %	30 %
Mokelumne	Fall[a]	2,000,000	100 %	0
Merced	Fall	300,000	0	100 %
Totals		**34,500,000**	**41 %**	**59 %**

a Central Valley fall-run produced for fishery enhancement purposes, funded by the commercial salmon trollers enhancement and restoration group.

Analysis of Chinook salmon otoliths in 1999 and 2002 found that the contribution of hatchery-produced Chinook salmon 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). More recently, estimates based on data from the 2012-2014 Central Valley coded wire tag recovery indicated the proportion of CV Chinook salmon in the ocean associated with hatchery production was 70 percent (Palmer-Zwahlen et al. 2018; Palmer-Zwahlen et al. 2019; Palmer-Zwahlen and Kormos 2015). The large influence of hatchery fish on the productivity of CV Chinook salmon likely results from numerous factors that may include decreased survival rates of natural production in the system, and increasing survival rates of hatchery production as hatchery release practices have been modified over time to improve survival of hatchery fish through the system (e.g., release of hatchery production directly into San Francisco Bay 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 population, 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 an Opinion that concluded the effects resulted in an appreciable reduction in both the survival and recovery of SRKW and developed, in coordination with Reclamation and DWR, a Reasonable and Prudent Alternative (amended in 2011) with 72 actions, some of which would contribute to avoiding jeopardizing the continued existence of the SRKW. The 2009 Opinion quantified effects of hatchery production and project operations on non-listed Chinook salmon available to SRKW 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 diminishing the long-term viability of non-listed CV Chinook salmon stocks the RPA called for development of hatchery management plans for fall-run Chinook salmon at Nimbus Fish Hatchery and for 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 SRKW in the long term.

Since the completion of the 2009 Opinion, an HGMP has been developed for the Trinity River Fish Hatchery but not for Nimbus. 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 Livingston Stone National Fish Hatchery in 2017. The Nimbus HGMP was not completed by 2014 as required in the RPA, however, Reclamation is proposing to complete the HGMP as part of the proposed action and within six months of completion of the consultation will work with CDFW and NMFS to establish a clear understanding on this conservation measure's goals, appropriate time horizons, and reasonable cost estimates for this effort. The HGMP will describe hatchery operations and associated monitoring to reduce genetic introgression from the out-of-basin Nimbus Hatchery broodstock, implement practices to reduce straying, and eliminate inter-basin transfers from Nimbus hatchery, all of which should improve the fitness of Nimbus fall-run Chinook salmon.

While ongoing hatchery production at current levels is expected to continue to negatively affect survival, productivity, and genetic diversity of naturally-produced fish in the Central Valley, the proposed development of the Nimbus HGMP and continued implementation of other HGMPs developed since 2009 are expected to minimize these impacts. In addition, as the primary component of CV Chinook salmon escapement to the ocean, hatchery production serves to stabilize the abundance of Chinook salmon available as prey to SRKWs given current declines in natural production and uncertainty associated with predicting CV Chinook salmon responses to the proposed action and future environmental conditions.

8.8.3 Linking Hatchery and Natural Production to Ocean Abundance

In order to relate the comparative impact of the proposed action to current operating scenario in terms of the overall ocean abundance of CV Chinook salmon, we first examined the relative contribution of hatchery production (released in-river and directly into San Francisco Bay as described above) and natural production to recent ocean abundances of CV Chinook salmon, in order ultimately relate the relative impact of the proposed action compared to current operating scenario to each component as described above. The hatchery and natural proportions of CV Chinook salmon were estimated based on data from the 2012-2014 Central Valley coded wire tag recovery reports (Palmer-Zwahlen et al. 2018; Palmer-Zwahlen et al. 2019; Palmer-Zwahlen and Kormos 2015). Over these years, the proportion of fish recovered that were of hatchery origin averaged 0.70 (range 0.65 – 0.75). Using the median ocean abundance of CV Chinook salmon for the period 2001 – 2018 of 454,052 (age 3+), along with the assumed hatchery proportion of 0.7, and the median number of hatchery-produced Chinook salmon that survive and/or are released into San Francisco Bay under current operating scenario (16,831,019), 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 J). In addition, using this same information we can estimate that contribution of naturally produced CV Chinook salmon in San Francisco Bay would have been 7,213,294 juvenile smolts.

From this point, it is possible to combine the upstream and delta survival effects under the proposed action compared to current operating scenario for all hatchery and naturally produced CV Chinook salmon and project these results in terms of changes in the adult (age 3+) ocean abundance of CV Chinook salmon under the proposed action compared to current operating scenario, including results from winter-run Chinook salmon IOS model runs. Using estimates of ocean abundance from 2001 to 2018, the percent change in abundance is a 0.21 percent decrease (~950 adult Chinook salmon) at the median value, and a 2.21 percent (~9,700 adults) decrease at the 2.5 percentile and 2.43 percent increase (~12,600 adults) at the 97.5 percentile (Table 132; Appendix J), representing a broad range in potential abundance. In 2019, the Pacific Fishery Management Council estimated 1,460,800 Chinook in the ocean. If the project reduces the Sacramento Index (an estimate of Central Valley Chinook salmon production based on fall-run Chinook salmon) by a median of -0.21 percent, this would constitute a 0.05 percent reduction in Chinook in the total number of Chinook in the Pacific Ocean available for prey. This is likely an underestimate of the change in prey available to SRKW during the months they forage offshore of the coast of Oregon, Washington and California, as this is a smaller area than that encompassed by the Pacific Fishery Management Council total and these non-summer months have been identified as a time of year with low Chinook salmon prey availability for SRKW. Therefore, the magnitude of prey reduction compared to the total prey base is still small, but likely larger than this quantitative estimate. We recognize these results may not be representative of the total extent of relative changes in impacts under the proposed action, but serve as the best available estimate of proposed action effects on available prey.

Table 132. Abundance of Central Valley Chinook salmon available as prey for Southern Resident killer whales under the current operating scenario and proposed action scenarios and change in abundance between scenarios.

	Median	97.5 %ile	2.5 %ile
Natural Chinook smolts in Bay baseline (COS)	7,213,294	7,345,971	7,212,754
Natural Chinook smolts in Bay in PA	7,199,260	7,829,734	6,654,245
Hatchery juvenile Chinook total in Bay COS	16,831,019	19,710,070	16,082,252
Hatchery juvenile Chinook total in Bay PA	16,792,102	19,647,691	16,135,970

	Median	97.5 %ile	2.5 %ile
Total juvenile Chinook in Bay (COS)	24,044,313	27,056,041	23,295,006
Total juvenile Chinook in Bay (PA)	23,991,362	27,477,426	22,790,215
Bay to ocean adult survival	0.0189	0.0189	0.0189
Ocean Adult Chinook Abundance (COS), not including winter-run	454,052	510,925	439,902
Ocean Adult Chinook Abundance (PA), not including winter-run	453,052	518,882	430,369
Adjustment for winter-run from IOS model			
Winter-run Chinook COS (IOS model)*	3,293	9,345	446
Winter-run Chinook COS to PA (proportional IOS model changes)	0.015	0.501	-0.450
Winter-run Chinook PA (IOS model changes)	3,342	14,024	245
Ocean Adult Chinook Abundance (COS)	**457,345**	**520,270**	**440,347**
Ocean Adult Chinook Abundance (PA)	**456,393**	**532,907**	**430,615**
Change in median number of Adult Chinook in the Ocean COS to PA	**-951**	**12,637**	**-9,733**
Percent abundance change in adult Chinook in the Ocean from COS to PA	**-0.21%**	**2.43%**	**-2.21%**
Change in Chinook Biomass (pounds) COS to PA**	**-16,067**	**213,435**	**-164,386**

**The median winter-run Chinook ocean abundance for 2001 to 2018 was used as the baseline in COS and proportional changes over the IOS modeling period are applied to that value.*

***Median adult weight of 16.89 pounds.*

8.8.4 Restoration Actions

In addition to the adverse impacts of continued operation of the CVP, Reclamation is proposing a number of restoration actions or programs to improve salmon production, growth and survival. Reclamation has proposed to conduct habitat restoration projects in the Sacramento River, American River, and Stanislaus River through 2030, as described in previous sections. Projects would occur annually with a goal to complete at least one habitat improvement project on each of these rivers each year. Cumulative habitat creation is proposed as 40 to 60 acres on the Sacramento River, 40 acres on the American River (based on 4.0 acres/year from among the identified sites), and 50 acres on the Stanislaus River. By 2030, an estimated 15,273 additional Chinook salmon could be available, assuming that habitats are otherwise at carrying capacity and that any new habitat translates directly into more fish (Appendix J). However, water operational factors are not figured into these estimates so these estimates cannot be directly aggregated with prey estimates. Restoration of 6,000 acres of tidal wetlands in the Delta is also expected 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 Chinook salmon in California's Central Valley.

8.8.5 Summary of Project Effects on Southern Resident Killer Whale Prey

Effects of the Proposed Action on Prey Abundance

There has been an ongoing apparent decline in the relative abundance of Chinook salmon over the 20 years for most Chinook salmon ESUs in the Central Valley, especially the dominant fall-run Chinook salmon populations, which has been occurring in concert with ongoing CVP operations along with other significant factors described in Section 7: *Environmental Baseline.* This is especially true for the dominant fall-run Chinook salmon populations, where escapement during most of the last 10 years has been substantially lower than previous time periods, primarily due to the effects of an extended drought. The proposed action includes both adverse and beneficial effects for Chinook salmon. Adverse effects are associated with water temperature and flow management and Delta export operations, while beneficial effects include pulse flows, habitat restoration, and other adaptively managed actions. Analysis of effects on ESA-listed Sacramento River winter-run and CV spring-run Chinook salmon ESUs are provided in previous sections of this Opinion. For non-ESA-listed species, the proposed action will likely continue to lead to diminished productivity of these populations, reducing the abundance of fall and late fall-run Chinook salmon.

The proposed action elements aimed at minimizing or offsetting the impacts of CVP operations to ESA-listed species are expected to also reduce the CVP impacts on non-ESA listed Chinook salmon productivity and abundance to some extent. Fall and late-fall CV Chinook salmon productivity and abundance are expected to benefit from proposed habitat restoration and efforts as more suitable habitat is made available. Management of diversion gates and pumping facilities to minimize juvenile entrainment are expected to improve juvenile survival and improve migration conditions for fall and late fall-run CV Chinook salmon.

Currently, hatchery fall-run Chinook salmon production represents a significant portion of the overall CV Chinook salmon productivity (approximately 70 percent), and significant effort is required to implement hatchery release programs designed to overcome low survival rates for juveniles through a large portion of the Central Valley system resulting from habitat conditions and stress created in part by ongoing components of the proposed action.

With respect to the proposed action compared to current operating scenario, the change in CV Chinook salmon abundance in the ocean is estimated to be relatively small (less than one percent median estimate). There are conflicting model results about the expected impact of the proposed action on the productivity of winter-run Chinook salmon, although winter-run Chinook salmon make up a very small percentage of the total amount of CV Chinook salmon productivity. 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 several hundred less adult CV Chinook salmon on average in the ocean under the proposed action compared to what might be available under current operating scenario. 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.

As discussed above, a number of restoration actions or programs that have been occurring, and are expected to continue into future, in addition to restoration actions included in the proposed action. These ongoing and new restoration actions are expected to improve Chinook salmon habitat, which is expected to improve productivity and abundance of CV Chinook salmon in the action area. By 2030 these restoration actions could result in several thousand additional adult CV Chinook salmon available as prey to SRKW.

Effects of Reduced Prey on SRKW

The information described previously in this Opinion suggests that the health of individual animals and the overall population dynamics of SRKW are related to the abundance of Chinook salmon available as prey throughout the range of SRKW. Reductions in availability of preferred prey (Chinook salmon) would be expected to influence the behavior and potentially affect the fitness of individual SRKW, and may affect the survival and reproductive success of SRKW. As described in the Section 6.9: *Southern Resident Killer Whale*, during the winter and spring, SRKW (particularly members of K and L pod) are likely to spend at least some time in coastal waters where they would be affected by reductions in CV Chinook salmon (especially fall-run Chinook salmon) abundance due to the proposed action. As described in *Impact of Prey Species* (Section 6.9.2), SRKW (particularly members of K and L pod) are linked to consumption of Chinook salmon from California based on the contaminant signatures discussed above. CV Chinook salmon, especially fall-run Chinook salmon, can constitute a sizeable proportion of the total abundance of Chinook salmon that is available throughout the coastal range of SRKW (about 20 percent on average, but varying substantially between ~10 and 30 percent during any given year). CV Chinook salmon become an increasingly significant portion of prey source during any southerly movements of SRKW 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 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 local abundance of Chinook salmon in some areas off California when SRKW are present there (Shelton et al. 2019).

With respect to short-term effects, SRKW 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). SRKW 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); Gamel et al. (2005)) and juveniles (e.g., Noren et al. (2009); 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 future productivity of offspring necessary to avoid extinction and promote recovery of a population.

8.9 LifeCycle Models

Life cycle models of winter-run Chinook salmon were used to analyze population abundance, cohort replacement rate, habitat use distribution, and juvenile survival differences between the current operating scenario and the proposed action. These models characterize the dynamics of multiple lifestages, including eggs, fry, smolts, juveniles in the ocean, and mature adults in the spawning grounds. The two life cycle models considered in this consultation were the Interactive Object-Oriented Simulation (IOS) Model, the results for which were provided by Reclamation (as supplemental ROC on LTO biological assessment modeling information), and the Southwest Fisheries Science Center’s Winter-run Chinook Life Cycle Model (WRLCM). Both the IOS model and the WRLCM provide a holistic evaluation in their examination of the effects of the action because both models consider the collective effects of multiple action components across the entire life-cycle. And while it is acknowledged that the underlying modeling (CalSimII and HEC-5Q temperature modeling) for both the IOS model and WRLCM does not capture or reflect the entirety of conditions associated with the current operating scenario and proposed action, the IOS model and WRLCM are considered the best available tools for assessing the effect of those conditions on winter-run Chinook salmon.

Given the unique set of results provided by the life cycle models, they are presented here instead of being integrated into, and possibly attributed to, an individual proposed action component. The results affect the population-level attributes of abundance, productivity, and population trend, rather than just an individual’s response described as a relative change in fitness. The analysis presented in this section is comparative and incorporates uncertainties in proposed action and current operating scenario modeling discussed in other effects sections. The comparative analysis is useful in terms of understanding the overall direction of modeled effects and assessing predicted trends on population structure and viability. As discussed in Section 2.4.2: *Analytical Approach*, this comparative analysis should not be conflated with an analysis of the full effects of proposed project operations on species. Section 11: *Integration and Synthesis* 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 effects of components of the baseline.

8.9.1 Interactive Object-Oriented Simulation Model Structure

The Interactive Object-Oriented Simulation (IOS) model is composed of six model stages defined by a specific spatiotemporal context and are arranged sequentially to account for the entire life cycle of winter-run Chinook salmon, from eggs to returning spawners. In sequential order, the IOS Model stages are listed below.

- 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.

- Early Development, which models the effect of temperature on maturation timing and mortality of eggs at the spawning grounds.
- 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.
- River Migration, which estimates mortality of migrating smolts in the Sacramento River between the spawning and rearing grounds and the Delta.
- 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.
- Ocean Survival, which estimates the effect of natural mortality and ocean harvest to predict survival and spawning returns by age.

8.9.1.1 IOS Model Results

For the first four years of the 82-year simulation period, the starting population of spawning adults for both scenarios is 5,000, of which 3,087.5 are female. In the fifth year, the number of female spawning adults is determined by the model's probabilistic simulation of survival to this life-stage. The model assumes all winter-run Chinook salmon entering the Delta are smolts and that there is no flow- or temperature-related mortality for the river migration (Red Bluff Diversion Dam to Freeport); a mean survival for this stage of 23.5 percent is applied with a standard error of 1.7 percent. Once in the Delta, the survival of smolts is characterized by the Delta Passage Model (Delta Passage Model) component in which flow, route selection, and water exports determine survival. In IOS, only timing into the Delta is altered from the standalone Delta Passage Model as spawning events and temperature determine migration towards the Delta.

IOS results show that egg survival is generally very high in most water year types but decreases substantially in critical years. Results for the two scenarios were similar, with median egg survival of 0.99 for both the current operating scenario and the proposed action (Figure 136). The x-axis is water year type (Wet, Above Normal, Below Normal, Dry and Critically Dry) and the y-axis is the proportion of egg survival.

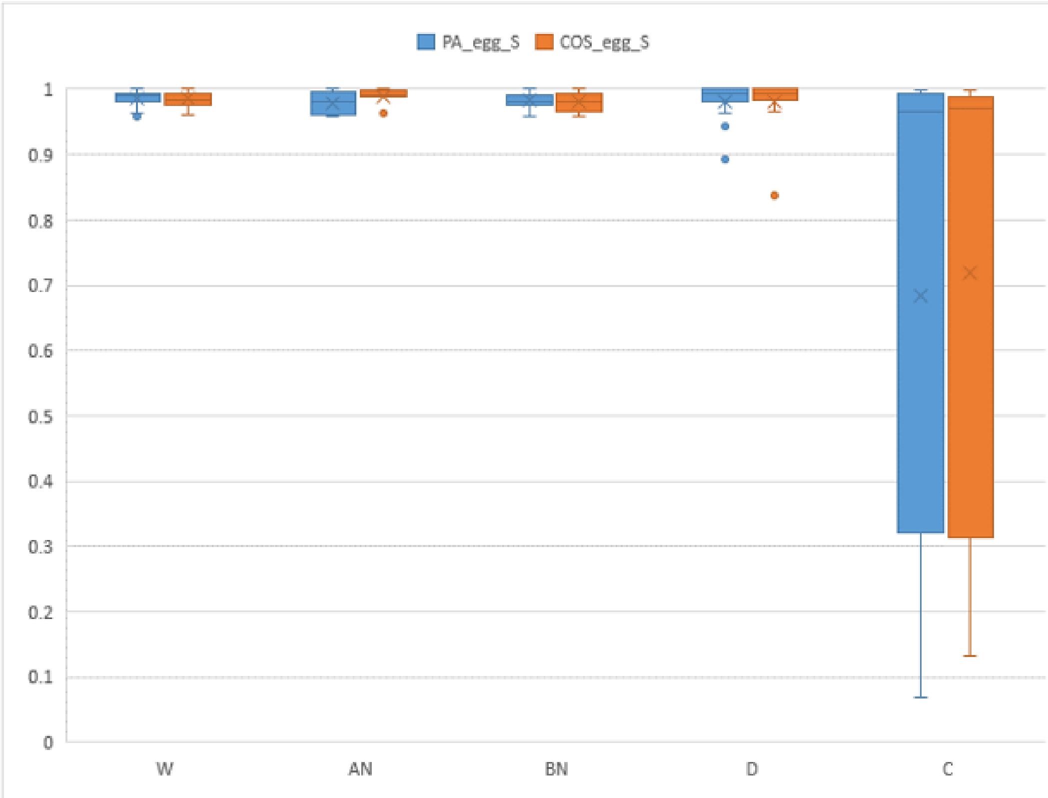


Figure 136. Box plots of annual egg survival for the current operating scenario and the proposed action for winter-run Chinook salmon estimated by the IOS Model by water year type.

Likewise, fry survival from Keswick Dam to Red Bluff Diversion Dam is temperature dependent and was very similar for the two scenarios with median fry survival for current operating scenario at 0.94 and for the proposed action at 0.95 (Figure 137). Here the x-axis is water year type (Wet, Above Normal, Below Normal, Dry and Critically Dry) and the y-axis is the proportion of fry survival.

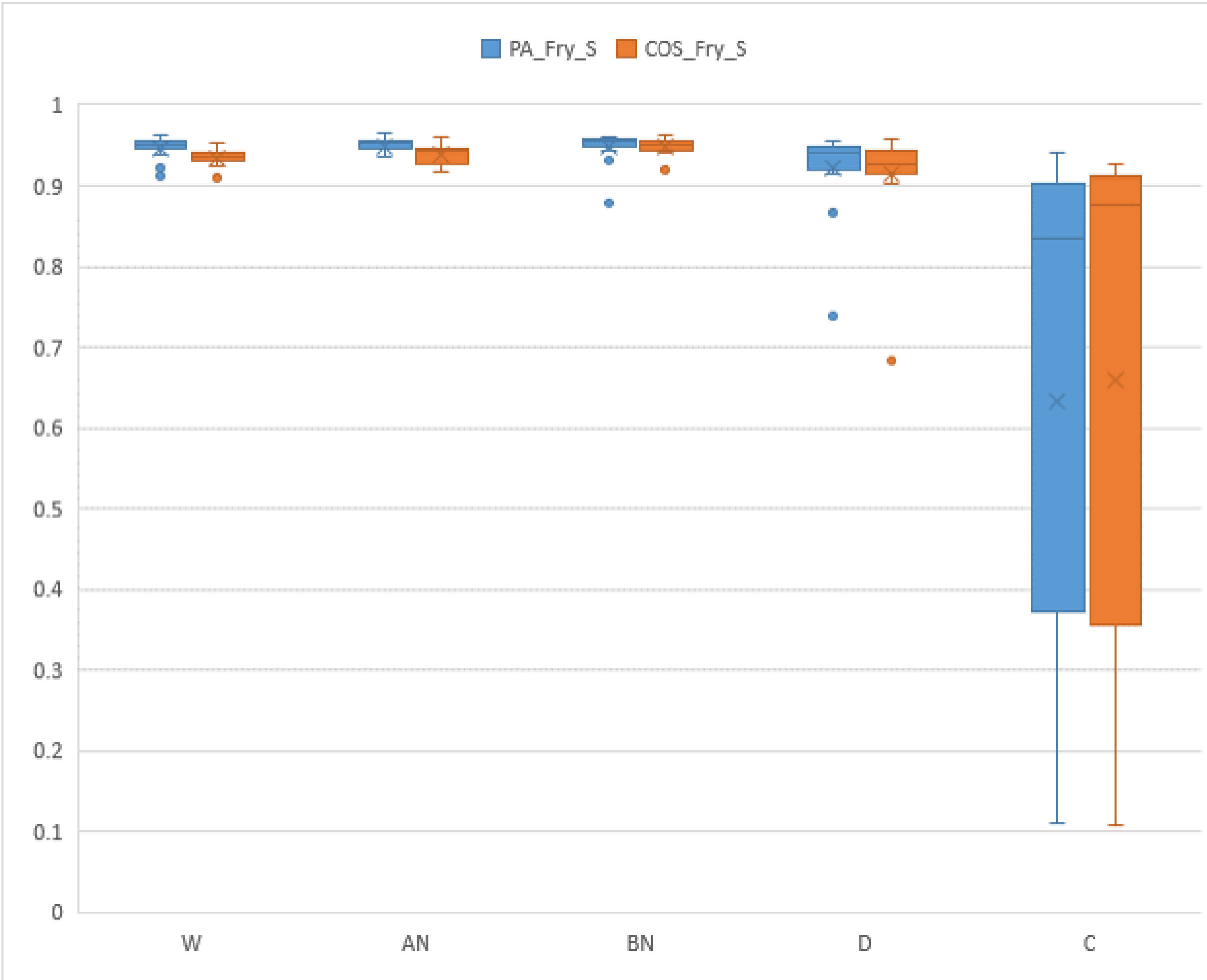


Figure 137. Box plots of annual fry survival for winter-run Chinook salmon from Keswick Dam to Red Bluff Diversion Dam estimated by the IOS Model between the current operating scenario and the proposed action separated by water year type.

Across all years, the IOS model's median predicted through-Delta survival was 0.41 for the current operating scenario and 0.42 for the proposed action (Figure 138).

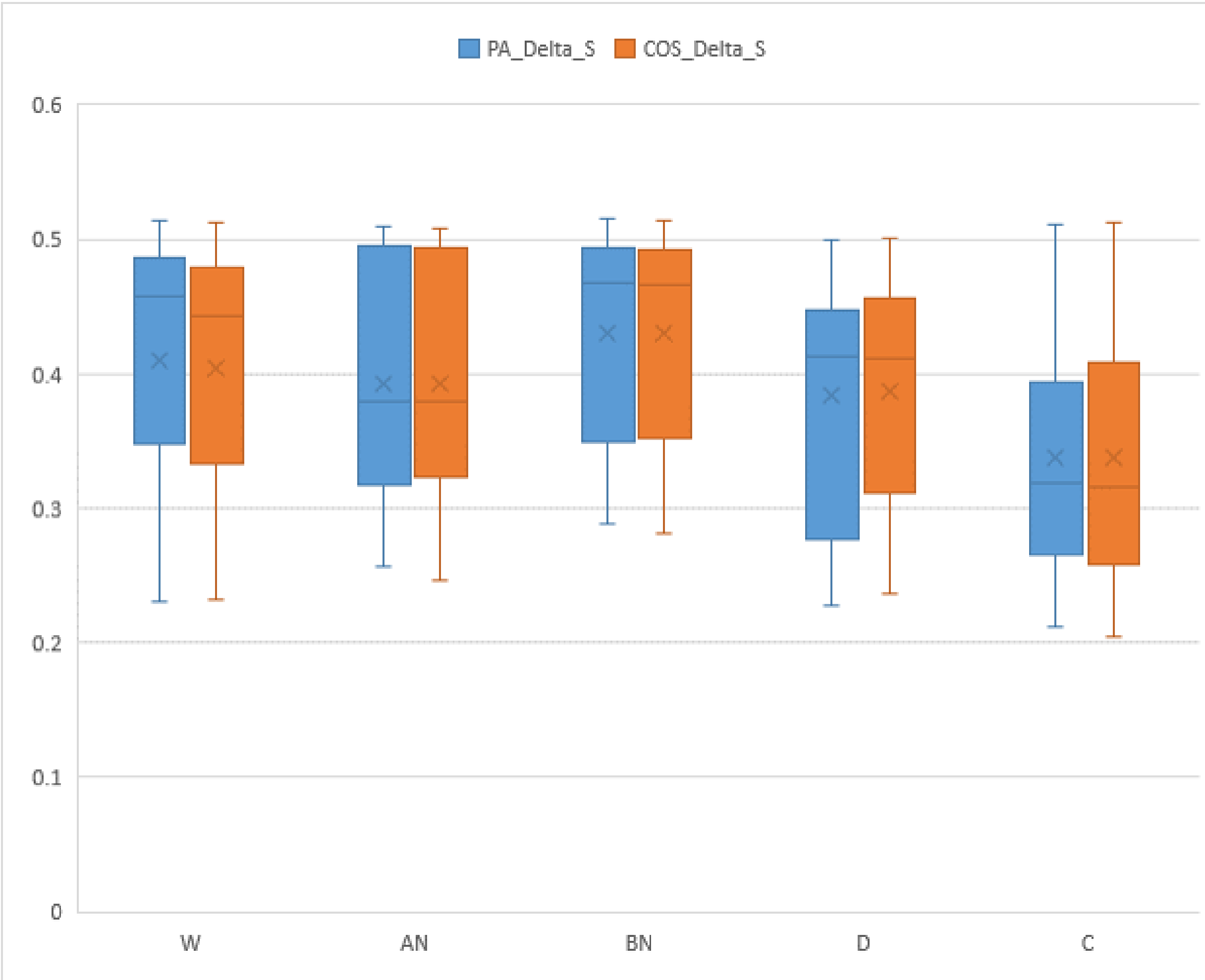


Figure 138. Box plots of annual through-Delta survival for the current operating scenario and proposed action for winter-run Chinook salmon estimated by the IOS Model by water year type.

In the IOS model, the probability of survival in the ocean is almost identical for both the proposed action and current operating scenario. The model predicts current operating scenario median adult escapement at 3,864 and proposed action median escapement of 3,909, a population difference of 1.2 percent (Figure 139). In other words, the model predicts a 1.2 percent increase of adult spawners for the proposed action.

Throughout the life cycle of winter-run Chinook salmon, the IOS model identifies very little difference in results between the current operating scenario and the proposed action. Based on the IOS model, fry survival is the stage most affected by the proposed action, with an increase of 1.2 percent. IOS results show survival probabilities are similar for both scenarios for all stages, attributing the 1.2 percent increase in escapement to the increased fry survival for the proposed action. The differences in escapement based on water year type is not a reflection of hydrologic conditions for the outmigrating juveniles; instead, it is a classification of hydrology for the time when adults returned to spawning grounds.

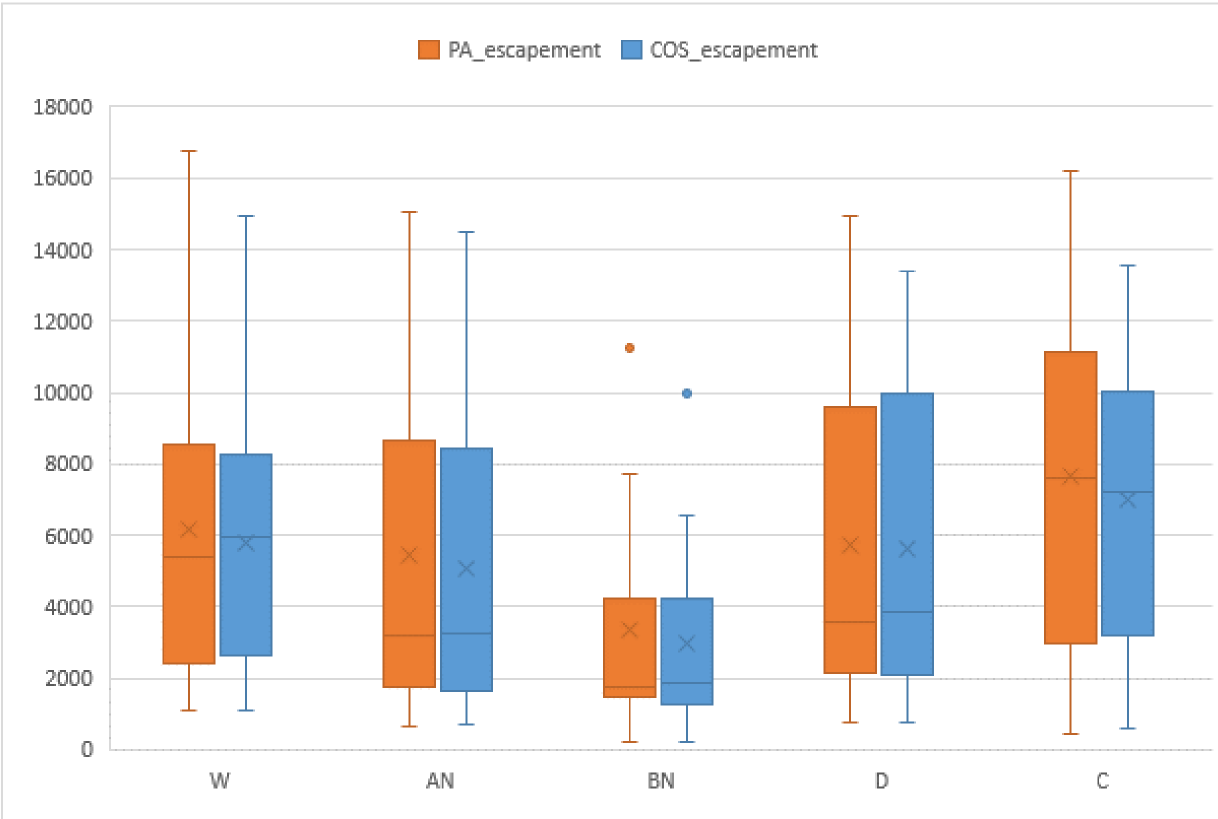


Figure 139. Box plots of annual escapement for the current operating scenario and the proposed action for winter-run Chinook salmon estimated by the IOS Model by water year type.

8.9.2 Sacramento River Winter-run Chinook Salmon Life Cycle Model

A state-space life-cycle model for winter-run Chinook salmon in the Sacramento River developed by the Southwest Fisheries Science Center was used to analyze differences between the current operating scenario and proposed action. The model has multiple 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 smoltification to Chipps Island by applying equations from analysis of reach specific survival in the Delta (Newman 2003). The model 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 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.

For survival in the Delta, the WRLCM uses Newman (2003) survival results, which are based on a statistical model and environmental covariates that occurred over the time frame 1979-1995.

We also note that the Newman model was developed using juvenile fall-run Chinook salmon reared in hatcheries and released in April and May, which is later than the peak outmigration for winter-run Chinook salmon. While there are more recent evaluations of survival through the Delta, these approaches have yet not been incorporated into the development of the WRLCM and were therefore not available at the time of the evaluations for this Opinion. NMFS acknowledges that a level of uncertainty is introduced by using the older information of Newman (2003), and consider this when evaluating the multiple lines of evidence of the WRLCM and other analytical tools.

The current operating scenario and the proposed action were run for each of the 1,000 parameter sets. It is important to note that the current operating scenario and proposed action should be evaluated in a relative sense using the WRLCM, because relative comparisons are more robust than the absolute predictions from the WRLCM. Moreover, it would be incorrect to equate outputs of the model as equating to actual numbers of fish in the Sacramento River. This perspective is adopted for several reasons: 1) the underlying hydrology of the current operating scenario and the proposed action are based on CalSimII model outputs that are a combination of historical hydrology and future expected hydrological 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 CalSimII results (HEC-RAS, DSM2, and Newman (2003)) require assumptions that would all need to be true; and 3) the WRLCM was not calibrated to produce forecasts of actual abundances. As a result, the WRLCM should be viewed as a tool that can provide guidance on the relative performance of the two sets of operations, and the percent difference (i.e., (proposed action – current operating scenario)/current operating scenario * 100 percent) was computed for each of the 1,000 model runs.

A detailed description of the model methods and assumptions, as well as all the scenario results, are contained in the Appendix A of this Opinion.

The model was applied in a scenario that compared the proposed action to the current operating scenario using an initial abundance of 10,000 spawning adults as a representative population of 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 82-year historical CalSimII record from 1922 to 2002. 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 proposed action and the current operating scenario due to the initialization period) and afterward are used to calculate the abundance and cohort replacement rate metrics.

8.9.2.1 Results of the Scenario Evaluation

Overall, the WRLCM results indicate higher abundances and lower cohort replacement rate for the current operating scenario relative to the proposed action. Mean abundance is 3.05 percent less for the proposed action relative to current operating scenario through the modeled time series (Figure 140). The probability that average abundance for the proposed action would be greater than average abundance for the current operating scenario in the 82-year time series is approximately 0.03. That is, of the 1,000 paired runs of the current operating scenario and proposed action, there were 30 in which the average modeled abundance for the proposed action was greater than the average modeled abundance for the current operating scenario, leading to a probability of 0.03.

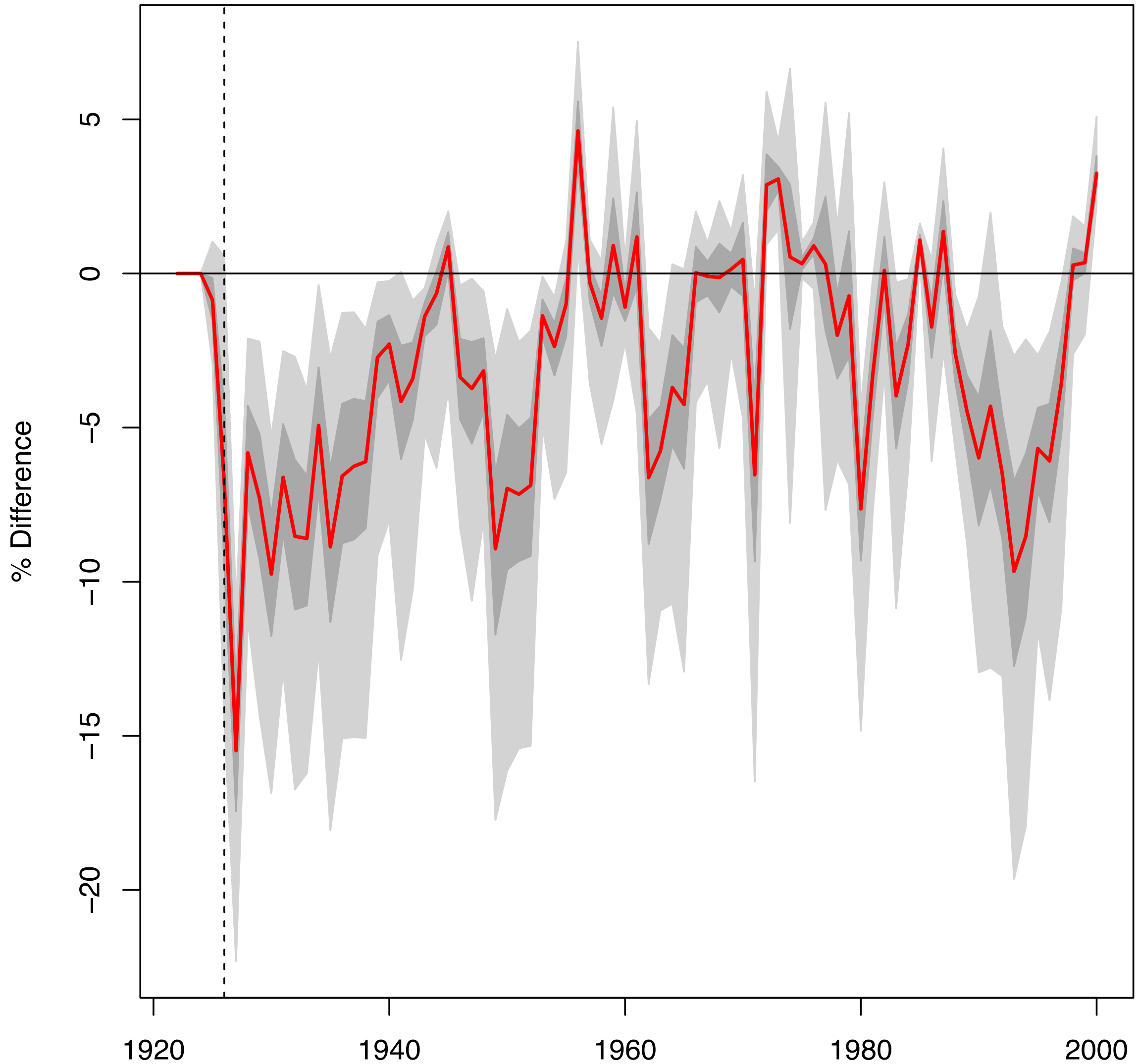


Figure 140. Difference in abundance ((PA – current operating scenario)/current operating scenario X 100 percent) for 1,000 paired runs of the WRLCM incorporating parameter uncertainty and ocean variability. Results show median (red line), 50th percentile interval (dark grey) and 95th percent interval (light gray).

The cohort replacement rate 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 cohort replacement rate for 1,000 paired runs of the WRLCM indicate that there is a 0.993 probability that cohort replacement rate would be higher for the proposed action than the current operating scenario over the 82-year model period. There is a consistent difference over the model period because density dependence in the spawning stages will cause the cohort replacement rate 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 of eggs per spawner affects the cohort replacement rate negatively, leading to reduced cohort replacement rate for higher abundances. Furthermore the mean cohort replacement rate of the proposed action is only 0.55 percent greater than the mean cohort replacement rate of the current operating scenario (Figure 141). This number indicates that the population's ability to replace itself is, numerically, slightly improved for the proposed action, but that is partially driven by the relative decrease in abundance for the proposed action. Overall, the mean difference in cohort replacement rate between the proposed action and current operating scenario may be so small that it does not represent a biologically meaningful difference.

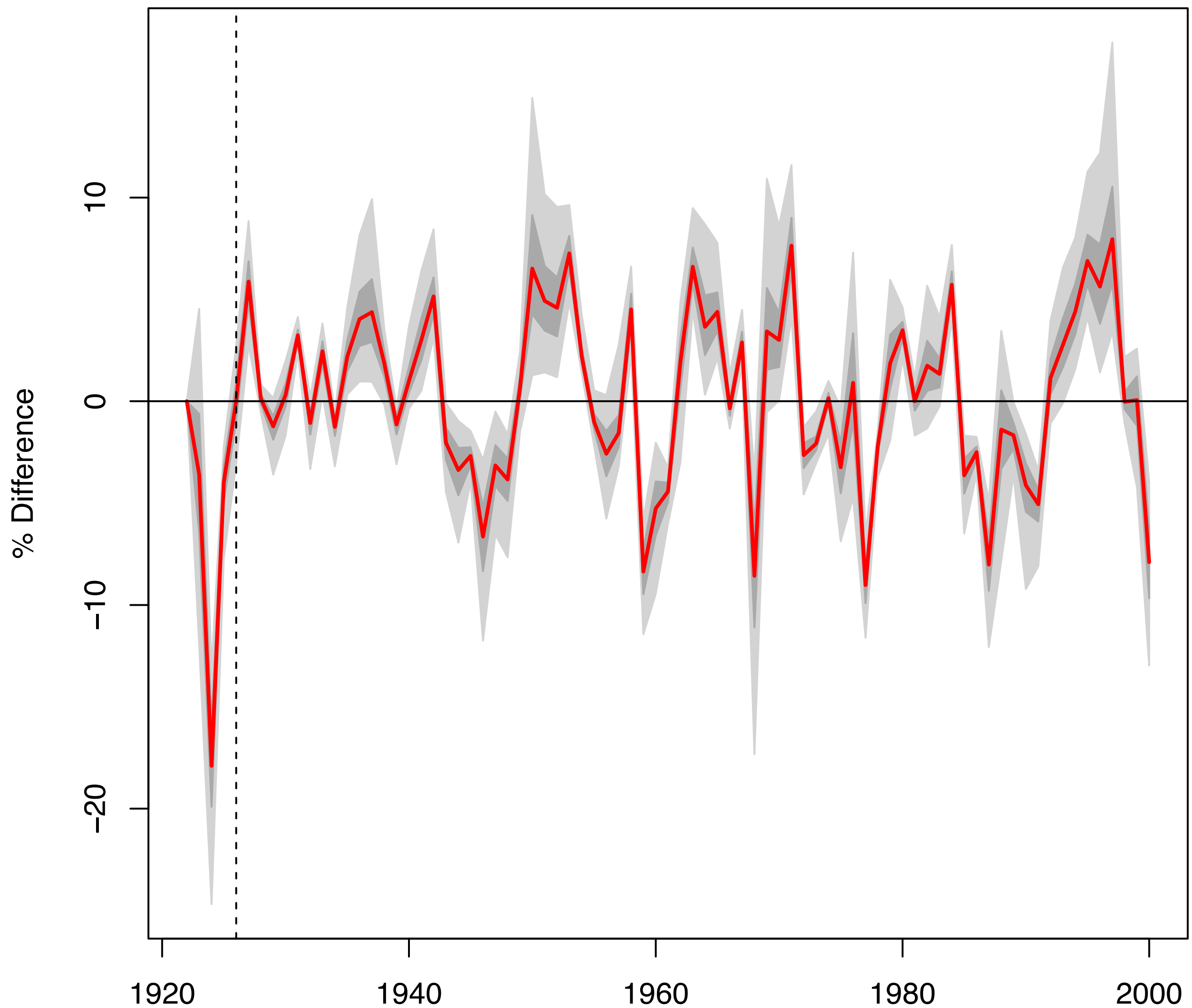


Figure 141. Difference in cohort replacement rate (i.e., (PA – current operating scenario)/current operating scenario X 100 percent) for 1,000 paired runs of the WRLCM. Results show median (red line), 50th percentile interval (dark grey) and 95th percent interval (light gray).

8.9.3 Dynamics Leading to Differential Abundance and Productivity

The lower abundance in the proposed action relative to the current operating scenario are largely due to conditions in the non-wet water year types and the month of April in certain lifestages/locations. There is little difference between the proposed action and current operating scenario in the egg-to-fry mortality that occurs in the reach from Keswick Dam to Red Bluff Diversion Dam, except for minor differences in the months of June - August in Critical water year types (Figure 142). During Critical water year types, the model shows that the proposed action has a decreased median survival, specifically in August (a reduction of 5.6 percent).

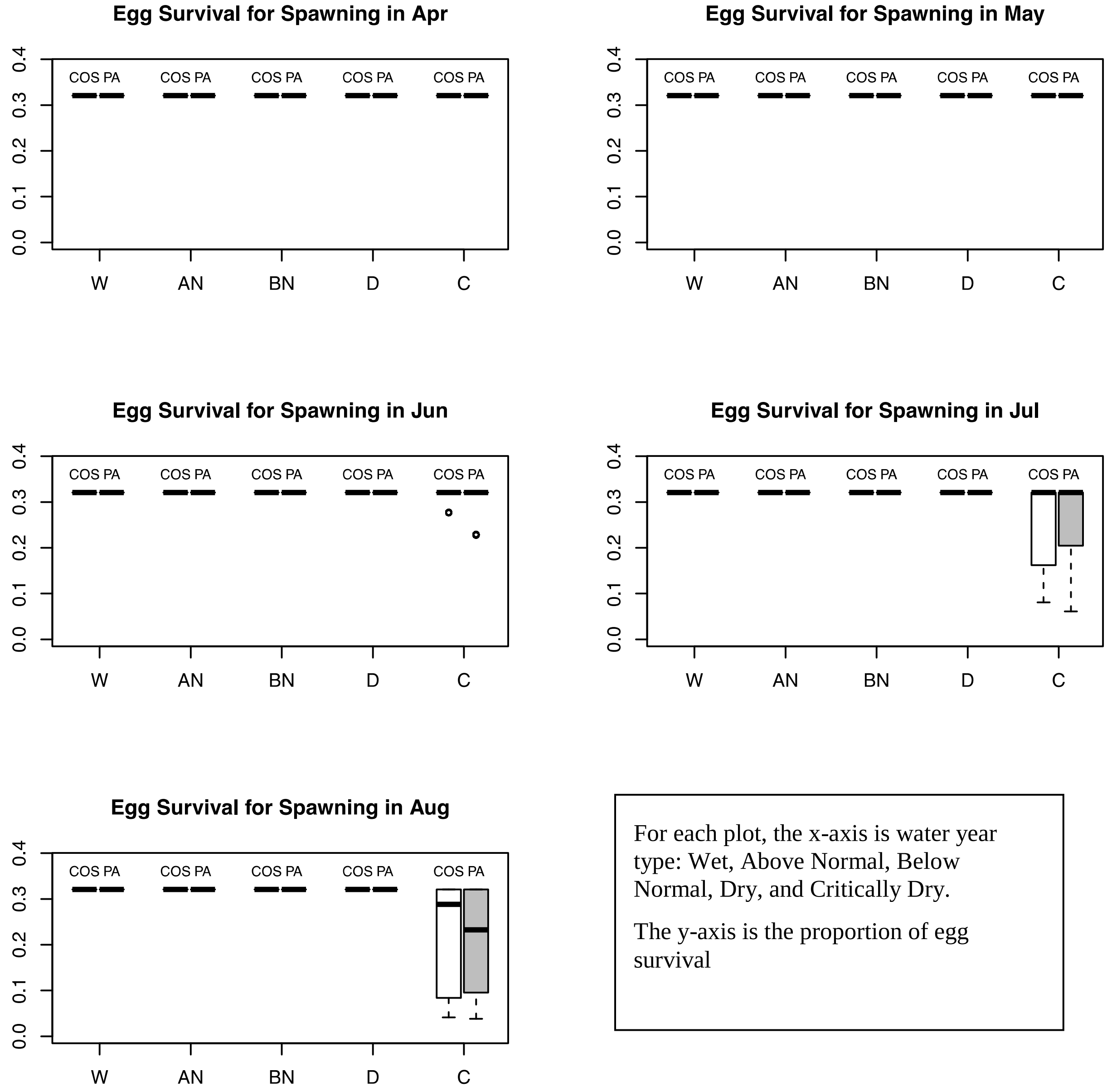


Figure 142. Egg-to-fry survival by month for the current operating scenario and proposed action.

Likewise, there are small differences in the survival of smolts originating from the Upper River habitat (Figure 143); the Upper River habitat begins below Keswick Dam and ends at the Red Bluff Diversion Dam. In all months and water year types, survival of smolts originating in the Upper River was lower for the proposed action except for January through March of wet years, when survival for the proposed action was slightly greater than for the current operating scenario (Figure 143). For all water year types, the differences in smolt survival between the proposed action and current operating scenario are very small, being less than 3 percent different except for April of below normal years when current operating scenario survival is 3.6 percent greater than the proposed action.

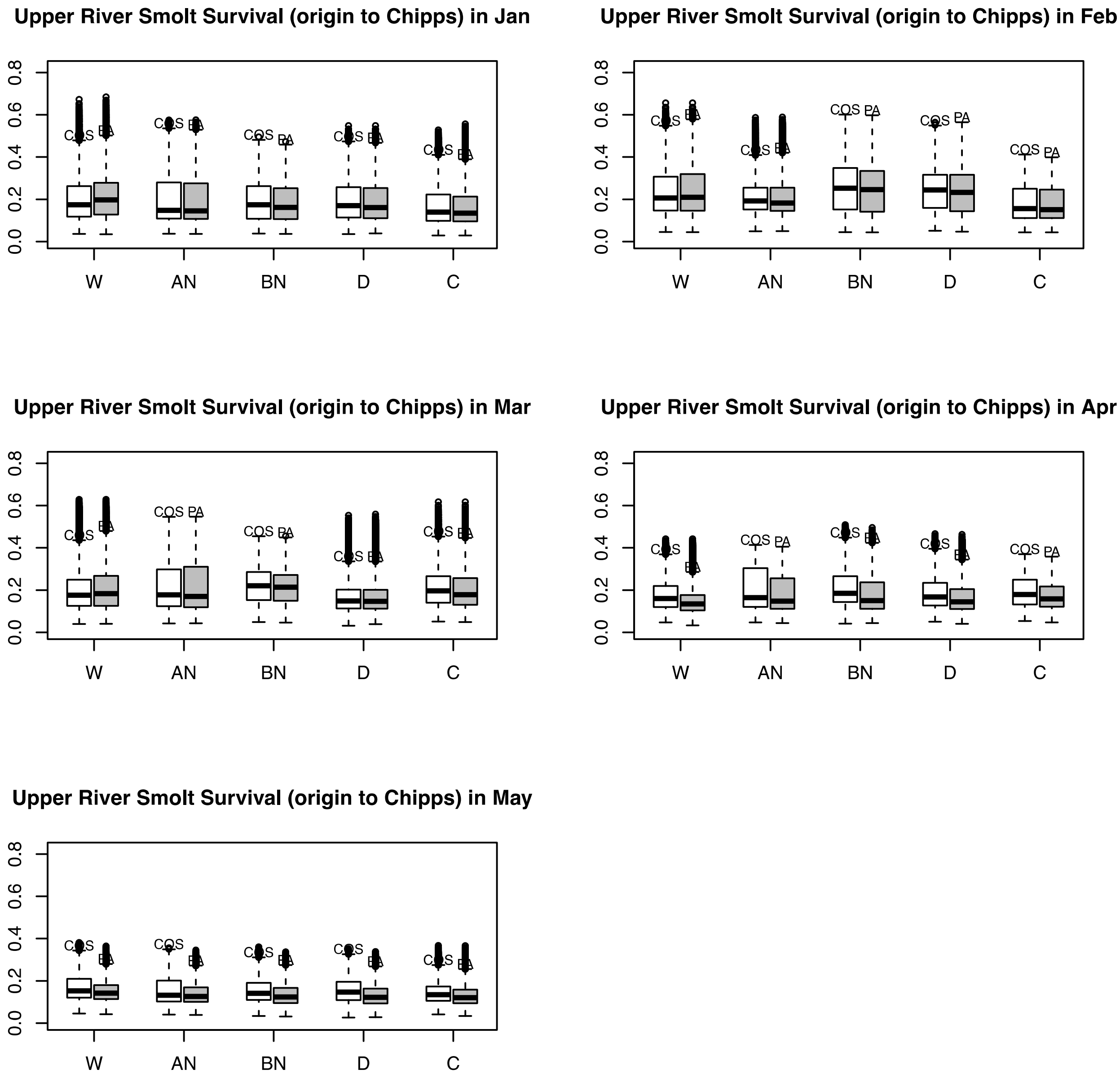


Figure 143. Monthly survival of smolts originating from the Upper River habitat under current operating scenario and proposed action.

Similar to the analysis of survival of smolts originating in the Upper River habitats, survival of smolts originating in the Lower River habitats is generally lower for the proposed action than the current operating scenario (Figure 144). The Lower River habitat begins below Red Bluff Diversion Dam and ends at the Delta. Survival for the proposed action was lower than current operating scenario in all months and water year types except for January through March of wet years, when proposed action survival is slightly greater than current operating scenario survival (Figure 144). Of the months examined, April has the greatest difference in survival of smolts originating in the Lower River habitats; in this month, proposed action survival is 3.6 to 7.5 percent lower than current operating scenario survival.

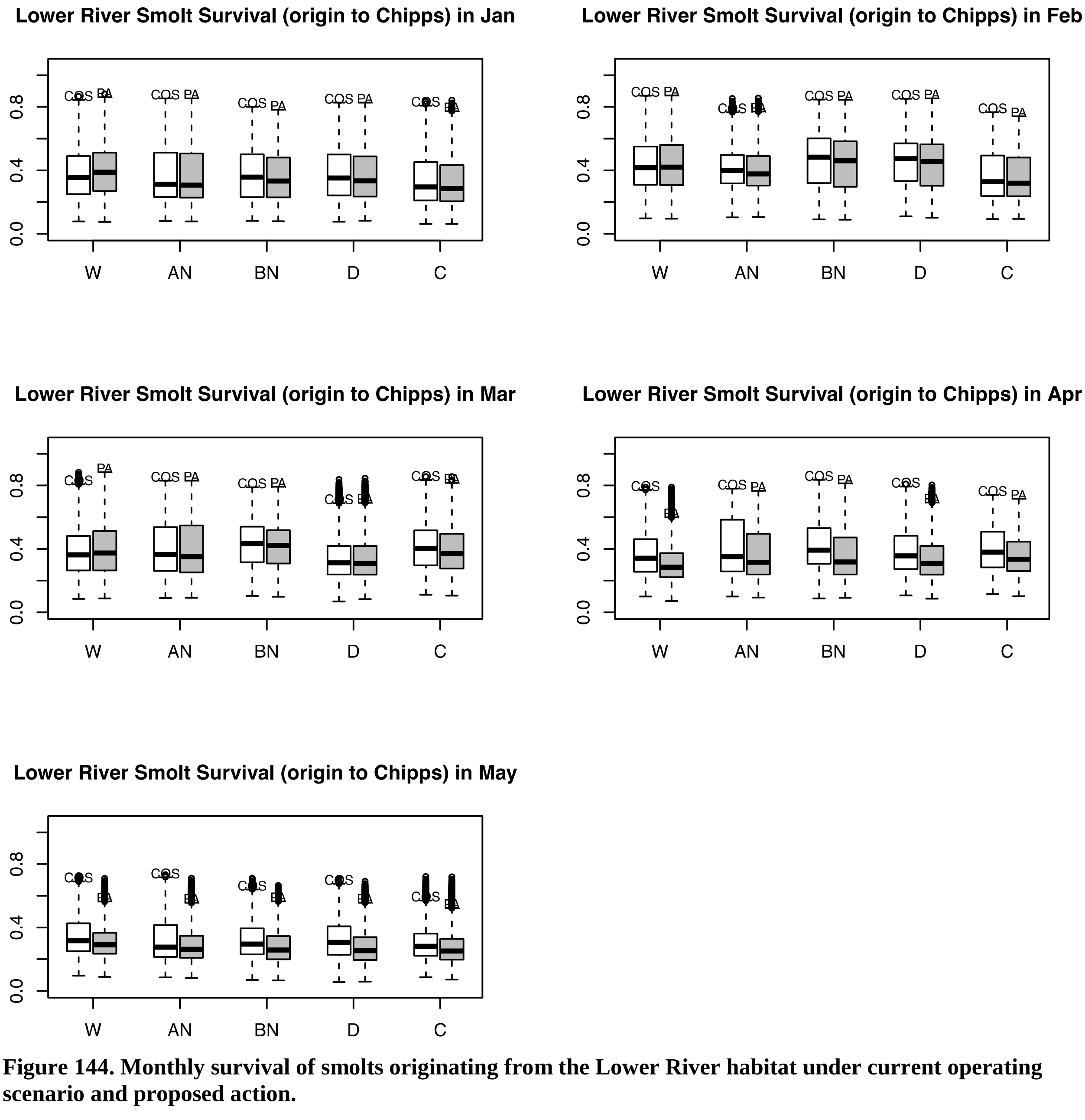


Figure 144. Monthly survival of smolts originating from the Lower River habitat under current operating scenario and proposed action.

Overall, the results show similar survival for smolts originating from the Delta habitat for both the proposed action and the current operating scenario (Figure 145). Smolts that originate in the Delta have slightly lower median survival for the proposed action during most months and water year types. All survival differences for the proposed action relative to the current operating scenario are less than 3 percent, except for the month of April, when median survival for the proposed action is 4.8 to 9.4 percent less than for the current operating scenario. The difference in smolt survival for the proposed action relative to the current operating scenario reflects differences in flow in the Delta region. For the proposed action, higher south Delta export levels influence in-Delta flows, reducing survival relative to the current operating scenario; therefore, smolts that originate from the Delta habitat may have slightly higher survival for the current operating scenario than the proposed action (Figure 145).

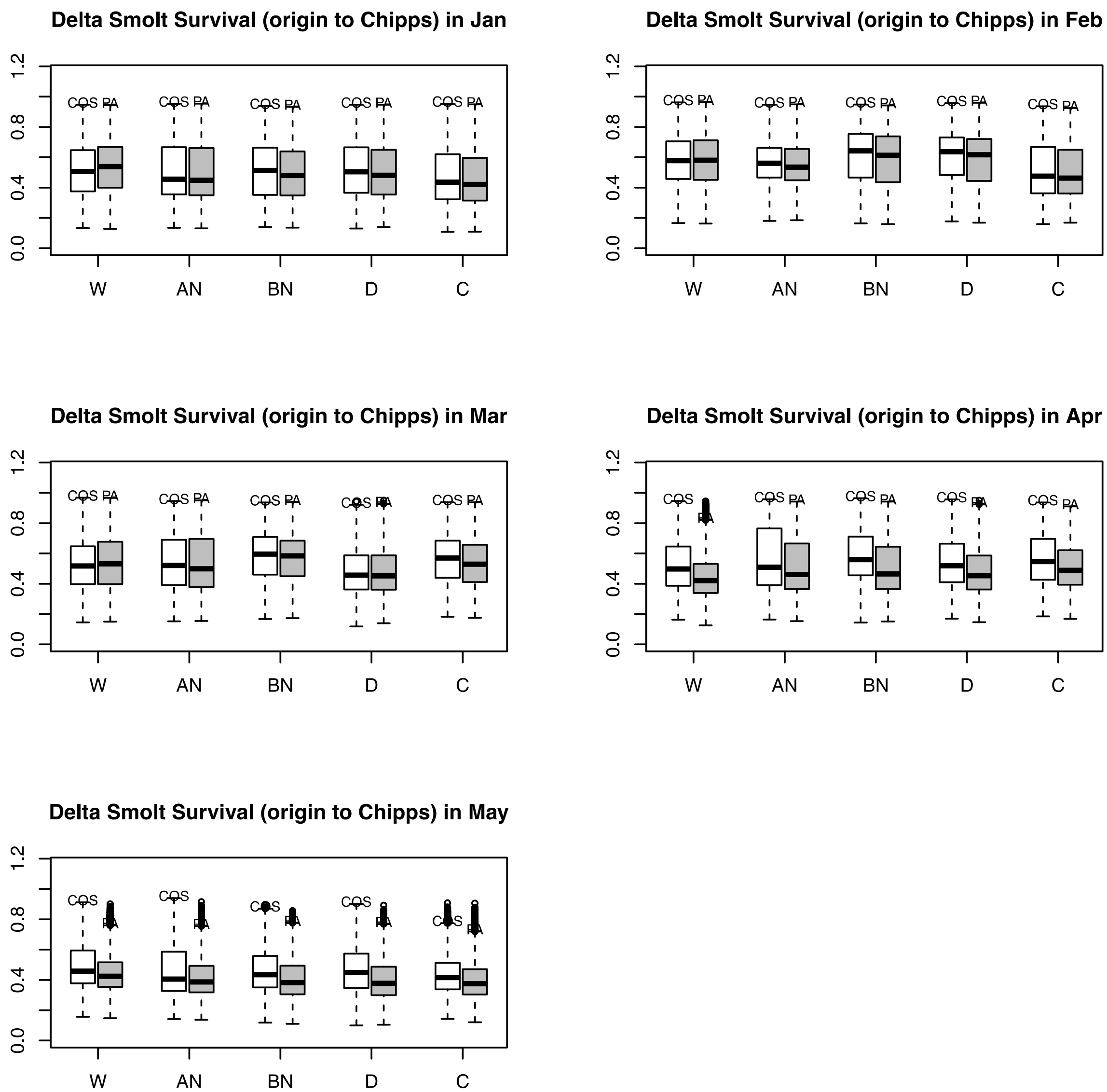


Figure 145. Monthly survival of smolts originating from the Delta Habitat for the current operating scenario and proposed action.

In general, survival results of the proposed action are slightly lower than the current operating scenario during most months and water year types. These results are particularly noticeable in April for all water year types. Results are shown for Jan-May for all habitat types and do not imply equal distribution of presence in that habitat type for the full period.

As with the other habitats, smolt survival for the proposed action is lower than the current operating scenario for smolts originating in the Yolo Bypass habitat for all months and water year types, except for January through March of wet years, when the proposed action survival is slightly greater (Figure 146). The differences in survival between the proposed action and current operating scenario for smolts originating in the Yolo Bypass habitat are greatest in the month of April, when survival for the proposed action decreases 4.6 to 8.4 percent relative to the current operating scenario.

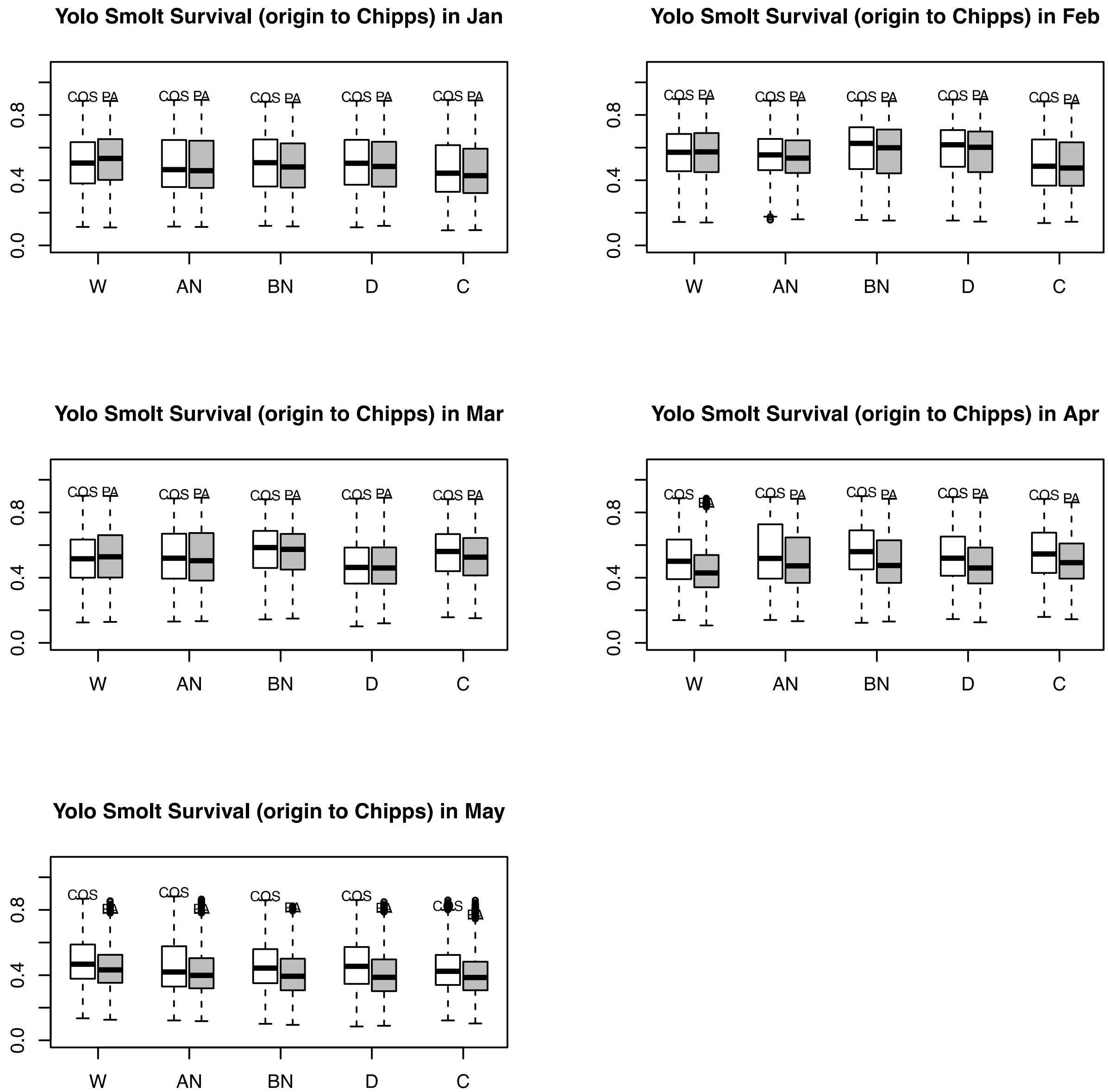


Figure 146. Monthly survival of smolts originating from the Yolo Habitat for the current operating scenario and proposed action.

In general, survival results of the proposed action are lower than the current operating scenario during most months and water year types. These results are particularly noticeable in April for all water year types. Results are shown for Jan-May for all habitat types and do not imply equal distribution of presence in that habitat type for the full period.

Overall, smolt survival based on habitat origin is lower for the proposed action compared to the current operating scenario. Whether this difference will affect the population dynamics in the winter-run life cycle model depends on the proportion of smolts that originate from particular habitats and the timing of emigration from the habitat or origin. Figure 147 shows the proportion of smolts originating from different habitat areas, including the Upper River, by water year type for the current operating scenario and proposed action. During wet years there is an increase in smolt per spawner for the proposed action compared to the current operating scenario (Figure 147); this difference is largely attributable to smolts originating in the Yolo Bypass habitat. This result highlights the importance of timing, since the proposed action has lower survival of smolts overall originating from the Yolo Bypass except for January through March of wet years (Figure 147). These differential patterns in habitat use and habitat-specific survival rates result in a slightly higher cohort replacement rate but lower abundance for the proposed action relative to the current operating scenario.

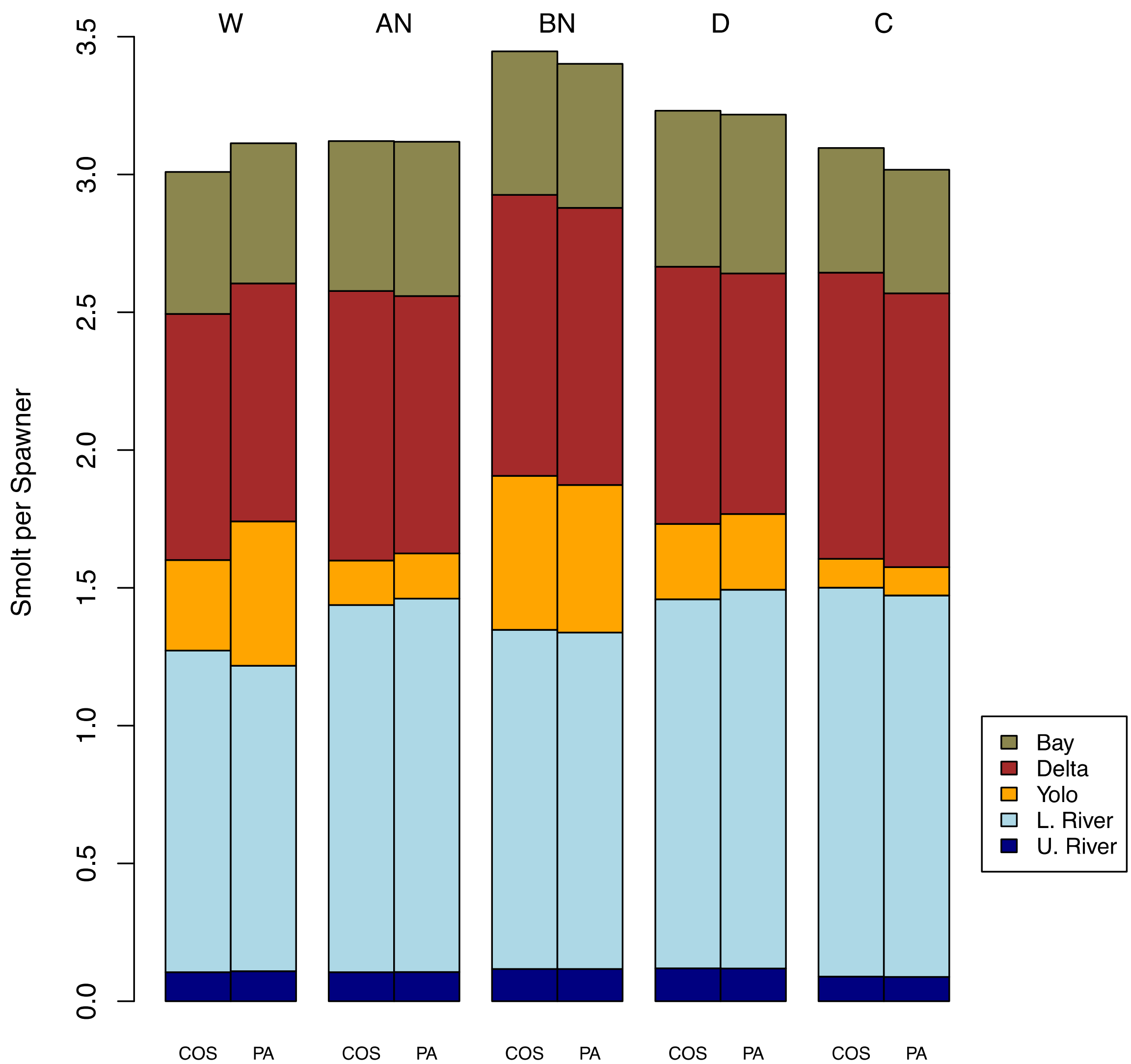


Figure 147. Origin of smolts by water year type for the current operating scenario and proposed action. Colors represent the habitat of origin.

8.9.4 Assessment of Population Decline Criteria

Lindley et al. (2007) identified the population decline criteria as a way of assessing demographic risks, where severe and prolonged declines to small run sizes are considered strong evidence that a population is at risk of extinction. The criteria have two components: a downward trend in abundance and a critical run size (i.e., less than 500 spawners). A downward trend in abundance is estimated as a 10 percent or greater decline in run size (i.e., abundance) per year. And while Lindley et al. (2007) notes that salmonid populations near a carrying capacity of 500 spawners with only modest intrinsic growth rates are typically at a low probability of extinction, it is important to point out that the threshold of 500 spawners lacks a robust justification. Likewise it is incorrect to equate outputs of the WRLCM to actual numbers of fish in the Sacramento River. Without actual numbers of fish, it is only appropriate to apply the WRLCM to provide guidance on the relative probability of a population decline and it is not a direct application of the Lindley et al. (2007) population decline criteria which includes whether abundance is below the critical run size.

To assess the relative probability of events in which the spawner abundance will decline by at least 10 percent over specified lag intervals of 1, 4, 12, and 20 years, the WRLCM was run for 1,000 iterations to represent multiple "states of nature." That is, in each of the model iterations it was calculated whether the abundance at the subsequent lag interval would have declined by 10 percent or greater. For a given iteration, the number of events with population declines of 10 percent or greater are assigned into three possible categories: (1) the number of events was higher for the current operating scenario than the proposed action, (2) the number of events were equal for the current operating scenario and proposed action, or (3) the number of events were lower for the current operating scenario than the proposed action. The probability of each category is then calculated as the number of iterations in each of the three categories divided by the total number of iterations (i.e., 1,000). The probabilities that result from this analysis do not indicate the specific probability of a decline occurring under each scenario at the specific lag. Instead, they indicate the probability that, over the 75-year timeframe of year 5 to year 82 (WRLCM is initializing in the first 4 years), the proposed action has fewer, an equal number, or more events than the current operating scenario in which the spawner abundance at the specified lag interval will decline 10 or more percent. That is, this metric evaluates the proportion of iterations for which these adverse events occur more often in the proposed action relative to the current operating scenario, occur the same number of times in the proposed action and current operating scenario, or occur less often in the proposed action than the current operating scenario.

Table 133 shows the relative probability of events in which the spawning abundance declines by more than ten percent over several time periods. The general pattern shows a higher number of events observed in iterations of the proposed action scenario relative to the number of events observed in iterations of the current operating scenario scenario over the 75-year timeframe. This is consistent for spawner abundances at lags of four and 12 years, with a shift toward more events for the proposed action relative to the current operating scenario at a lag of 20 years when compared to the other time periods.

Table 133. Relative probability of events in which there is a decline in spawner abundance of greater than ten percent at time lags of 1, 4, 12, or 20 years for the current operating scenario and proposed action.

	1 Year	4 Years	12 Years	20 Years
Pr (current operating scenario has more events)	0.265	0.235	0.296	0.171
Pr (equal number of events)	0.279	0.234	0.26	0.24
Pr (PA has more events)	0.456	0.531	0.444	0.589

This assessment also reflects the higher variability in the spawning abundance in the proposed action relative to the current operating scenario. The variance in spawner abundance for the proposed action is 6.23 percent higher than for the current operating scenario, with a 95 percent confidence interval of -0.263 percent to 12.3 percent relative to the variance of current operating scenario spawner abundance. The probability that variance is higher for the proposed action relative to current operating scenario is 0.971. Generally, a higher variance in the average spawner abundance of one scenario relative to another is described by larger swings in the spawner abundance, with higher peaks and lower lows. This pattern is shown in the relative percent difference plot of spawner abundance over time (Figure 140), where the variance is indicated by the year-to-year variability in the differences among years.

8.9.5 Summary

The IOS model and the winter-run life cycle model each have strengths and limitations in their ability to capture the dynamics associated with changes in species abundance and productivity in response to changes in physical conditions. Though the mechanistic basis differs between them, and this can lead to different results, we consider the comparative results of both models as lines of evidence in assessing the effects of operations to the species. The IOS results show little difference between the current operating scenario and the proposed action in egg survival, fry survival, or escapement. While the winter-run life cycle model shows a very slight increase in cohort replacement rate for the proposed action, the abundance for proposed action operations is on average less than for the current operating scenario. This three percent difference is not large in magnitude, but it does not support an opposite trend – that abundance of winter-run Chinook salmon would increase for the proposed action. We note again that while the comparative analysis of these results is useful in terms of understanding the overall direction of modeled effects and assessing predicted trends on population structure and viability, it should not be conflated with an analysis of the full effects of proposed project operations on the species. These results are analyzed in a comparative analysis between the two scenarios to place the difference in context given modeled operations; this difference is incorporated into the evaluation of effects in the aggregate. Considering these results together, NMFS believes that the effects of the operations of the proposed action would not increase abundance or productivity of winter-run Chinook salmon, but assumes that results would be similar to those of current operations.

8.10 Climate Change

In 2016, NMFS issued guidance for treatment of climate change in ESA decisions (Sobeck 2016). This guidance 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 considerations related to climate change that NMFS should use in ESA decision making, including ESA section 7 consultations. In addition to Sobeck (2016), NMFS regional guidance (Thom 2016) further recommends use of the Representative Concentration Pathway (RCP) 8.5 scenario from the Fifth Assessment Report (AR5).

The modeling of the proposed action as provided in the biological assessment characterizes a 2030 scenario of climate conditions, water demands, and build-out. In doing so, the proposed action uses a multi-model ensemble-informed approach to identify a best estimate of the consensus of climate projections from the third phase of the Coupled Model Intercomparison Project (CMIP3), which informed the Intergovernmental Panel on Climate Change's (IPCC) Fourth Assessment Report (AR4) (U.S. Bureau of Reclamation 2016a). This approach is the same as that used for other recent long-term operations evaluations (and is explained in further detail in Appendix 5.A of the Environmental Impact Statement for the Bay Delta Conservation). Because the 82-year sample set (1922 to 2003) of historic hydrology of the CalSimII model period is adjusted to capture the effects projected by the consensus approach, the modeling used in this analysis includes the occurrence of extreme but important events, such as the 1930s and 1990s droughts. These results are downscaled to a spatial resolution of approximately 12 km (7.5 mi). AR4 and its approach results in an anticipated temperature change of +0.7 to +1.4 °C (+1.25 to 2.5 °F) (representing the 25th to 75th quartile) and a precipitation change of -6 percent to +6 percent. Additionally, the approach used in the proposed action characterizes 2030 sea level rise of 15 cm (6 in) and a 2045 sea level rise of 45 cm (18 in).

However, based on results from the application of RCP 4.5 and RCP 8.5 in California's Fourth Climate Change Assessment (4th CA Assessment) (He et al. 2018; Pierce et al. 2018), NMFS expects that climate conditions will follow a more extreme trajectory of higher temperatures and shifted precipitation into 2030 and beyond. As provided by the 4th CA Assessment, NMFS assumes that temperatures would increase up to +1.9 °C (+3.4 °F) between 2020-2059 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 cm (6 in) in 2030 and 10-38 cm (4-15 cm) in 2050 (Pierce et al. 2018). This assessment uses CMIP5, which supersedes the CMIP3 archive of climate models scenarios used in in the previous California Climate Assessment, and better comports with NMFS and West Coast Region guidance on incorporating climate change into ESA decisions.

It is beyond NMFS' expertise, scope, and resources to develop model simulations that reflect the more updated climate projections provided in the 4th CA Assessment. This would require modifications to the base meteorological and hydrologic modeling that is the first, if not one of the very early, steps in the chain of models used to provide analytical tools to support the modeling (see Section 2.1.4.1 Primary Analytical Models for description of models used and data flow).

There is a notable difference in the projected air temperature increases between the modeling used for the biological assessment and the 4th CA Assessment. Compared to the biological assessment, the updated projected temperatures for the shorter-term (2025) in the 4th CA Assessment increase by more than 30 percent more; the difference in projections is nearly 1°C (1.8°F) warmer for the longer-term at 2100. These increases in air temperature can be expected to directly affect cold water pool and reservoir temperatures because of shifts to warmer storms, earlier snow melt, and increased or earlier solar warming of water in the reservoir. This would affect reservoir stratification and cold water pool setup, possibly beyond what can be predicted based on current understanding. Additionally, in-river summer water temperatures are already at levels that present challenges in managing to protect the species. Considering the 4th CA Assessment, NMFS expects that in-river temperatures will be even greater than what was presented in the biological assessment modeling; this will increase the management challenges in late-summer and fall months as reservoir cold water pools deplete over summer in efforts to keep downstream temperatures within a suitable range. NMFS cannot quantify the effect of this on species, but will assume that the provided modeling represents a scenario of lower effect and will layer additional qualitative evaluations of increased climate effects to the species based on the updated assessments.

The biological assessment modeling and the 4th CA Assessment projections of sea level rise are similar for 2030, but have greater differences for later projections. The higher projection of sea level rise in the 4th CA Assessment in the long-term 2100 scenario can be expected to increase salinity and tidal forcing in the estuary and Delta, which will reduce the effects of riverine flow. The difference in the 4th CA Assessment is especially apparent. No large-scale tidal restoration is included in the proposed action as designed to address this. It is, therefore, conceivable to expect modifications to proposed operations due to higher frequency of water quality excursions influenced by increased saltwater intrusion. There is also expected to be less seaward flow in highly tidal areas and tidally-influenced areas like the south Delta. Therefore, what was analyzed in the modeling of the biological assessment is considered by NMFS as the scenario of lower effect and consistent with the 4th CA Assessment for 2030; however, it is considered as an absolute lower effect for late 2000s when the assessment projects much greater increases in sea level rise than those captured in the modeling of 2030 in the biological assessment.

The effects of climate change are evaluated as imposed upon the behavior and distribution of the species as we understand it today. NMFS has not speculated, for instance, if and how species will adjust their migration timing to upstream reaches in response to changing climate conditions. Nor have we made any assumptions regarding species presence and density in response to changing conditions. Any shifts in species behavior and distribution that present conditions that are beyond the bounds of our analysis could be a reinitiation trigger, as the environmental baseline and status of species upon which we based this analysis would no longer be valid.

9 Effects of the Action on Critical Habitat

The destruction and adverse modification analysis considers whether the action produces "a direct or indirect alteration that appreciably diminished 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 physical or biological features essential to the conservation of a species or that preclude or significantly delay development of such features" (50 CFR 402.02).

This section addresses impacts to designated critical habitat for Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon. This analysis is organized within each Division by the physical or biological features of designated critical habitat.

9.1 Upper Sacramento/Shasta Division

Critical habitat impacted by the proposed action includes the Sacramento River from Keswick Dam to the Delta (301 miles). 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 winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon.

9.1.1 Effects to Salmonid Designated Critical Habitat

This section examines impacts to designated critical habitat for 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 physical or biological features. The physical or biological features for 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 action area provide the structure for the assessment of habitat impacts for all salmonids. For each habitat type, and each fish species, the specific physical or biological features that correspond to ESA-listed critical habitat are identified. Where there is discussion of effects to a specific component of a physical or biological feature, these are delineated by species.

9.1.1.1 Freshwater Spawning Sites

Freshwater spawning habitat for all three salmonid species occurs in the upper reaches of the Sacramento River from Keswick Dam to Red Bluff Diversion Dam. Spawning habitat is constrained by the availability of suitable temperatures during each species' respective spawning season, such that in the Sacramento River it is limited to a smaller area below Keswick Dam.

The existence of Shasta and Keswick dams limit 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 gravels beds, but not so high as to transport gravel out of the spawning area. Flows under the proposed action are generally similar to the current operating scenario and are unlikely to affect the amount of upstream gravel supplied by the tributaries or unregulated pulse flows. Reclamation's proposed spring pulse flow could provide flows high enough to flush fine sediments from spawning substrates, and the expected frequency of spring pulse flows is at most 75 percent of CalsimII years (could be less due to uncertainty of actual forecasting). In addition to operational measures that could affect the availability of spawning gravel, the proposed action also includes a number of projects to improve spawning habitat for Chinook salmon in the upper Sacramento River including adding clean gravel for spawning. It is likely that they would enhance availability of clean gravel for salmon spawning and are considered in the analysis of the proposed action. In addition, actions to improve fish passage at Deer Creek Irrigation District Dam will provide access to 25 miles of high quality spawning habitat, increasing the amount of suitable spawning habitat in the upper Sacramento River basin.

Flows in upper reach of the Sacramento River are similar for both the proposed action and current operations, and they are generally sufficient to provide for the successful spawning, incubation of eggs, fry development and emergence, and downstream transport of juveniles. Risk of redd dewatering is considered, especially with regards to swift reductions in flows during incubation periods. In their analysis, Reclamation provided an assessment of spawning weighted usable area for all Sacramento River salmonid species. Spawning weighted usable area provides a metric of spawning habitat capacity that accounts for the spawning requirements of the fish with respect to water depth, flow velocity, and substrate. Spawning weighted usable area for all three species of salmonids was determined by U. S. Fish and Wildlife Service (2003) and U.S. Fish and Wildlife Service (2006) for a range of flows in three segments of the Sacramento River between Keswick Dam and the Battle Creek confluence. The validity of the steelhead weighted usable area is less certain because of the difficulty in differentiating between steelhead and rainbow trout spawning (U. S. Fish and Wildlife Service 2003). Segment 4 stretches 8 miles from Battle Creek to the confluence with Cow Creek, Segment 5 reaches 16 miles from Cow Creek to the Anderson-Cottonwood Irrigation District Dam, and Segment 6 covers 2 miles from Anderson-Cottonwood Irrigation District Dam to Keswick Dam. Results are based on flow differences between the proposed action and current operating scenario with summary results combining all year types presented in Table 134. For winter-run Chinook salmon spawning habitat, decreased flows in September under the proposed action result in a decreased spawning weighted usable area in segment 6 but an increase in spawning weighted usable area in segment 5. For CV spring-run Chinook salmon spawning habitat, the months of September and November, when flows are reduced under the proposed action, show improved weighted usable area for both river segments 5 and 6. CCV steelhead spawning habitat also shows improved weighted usable area in November when the proposed action reduces Keswick releases, but otherwise there is slightly reduced weighted usable area under the proposed action.

Table 134. Spawning Weighted Usable Area results for Segments 5 and 6 for salmonid species in the upper Sacramento River.

		Segment 6			Segment 5		
Species	**Month**	**current operating scenario (COS)**	**Proposed Action (proposed action)**	**proposed action vs. COS**	**current operating scenario (COS)**	**Proposed Action (proposed action)**	**proposed action vs. COS**
Sacramento River Winter-run Chinook salmon	April	152,681	167,522	**14841 (10%)**	611,758	625,885	14127 (2.3%)
	May	268,429	274,858	6429 (2%)	765,140	765,962	822 (0.1%)
	June	296,167	290,571	-5596 (-2%)	759,746	724,260	-35486 (-4.7%)
	July	284,926	287,006	2080 (0.7%)	636,966	646,418	9452 (1.5%)
	August	298,982	297,206	-1776 (-0.6%)	774,943	775,706	763 (0.1%)
	September	237,708	224,608	**-13100 (-5.5%)**	678,419	724,884	**46465 (6.8%)**
Central Valley Spring-run Chinook salmon	October	238,206	236,731	-1475 (-0.6%)	748,370	748,740	370 (0%)
	August	265,774	267,457	1683 (1%)	399,815	399,362	-453 (-0.1%)
	September	265,823	301,301	**35478 (13%)**	430,673	542,720	**112047 (26%)**
	October	302,466	305,101	2635 (1%)	532,966	536,539	3573 (0.7%)
	November	160,675	196,159	**35484 (22.1%)**	466,553	547,148	**80596 (17.3%)**
	December	209,728	183,838	**-25890 (-12.3%)**	466,753	457,161	-9592 (-2.1%)
California Central Valley Steelhead	November	54,219	58,465	**4246 (8%)**	145,851	156,235	**10384 (7.1%)**
	December	55,389	51,426	-**3963 (-7%)**	137,830	133,910	-3920 (-2.8%)
	January	53,045	49,463	**-3583 (-7%)**	128,573	126,089	-2483 (-1.9%)
	February	49,420	47,132	-2288 (-4.6%)	116,522	117,445	923 (0.8%)
	March	53,270	52,951	-319 (-0.6%)	130,983	129,969	-1014 (-0.8%)
	April	110,197	109,431	-766 (-0.7%)	155,134	156,297	1163 (0.7%)

Orange indicates decrease in 5 or more percent; green indicates increase in 5 or more percent. Adapted from information provided by Reclamation

Water temperatures play a significant role in the function of salmonid spawning habitat. Both the current operating scenario and the proposed action can provide for suitable temperatures for spawning, egg incubation, and fry development based on the modeling. This is primarily attributed to the proposed temperature management modeling which shows an increased early summer storage volume, which could increase the frequency of meeting temperature criteria during the late spring, summer and early fall period. Even with the prescience associated with the hydrologic modeling, there are still months and years when temperatures are not suitable for spawning, egg incubation, and fry development. In some years, this is expected to reduce spawning success and survival of eggs and fry.

Of particular concern are temperatures in the months of August through October, which correspond to peak CV spring-run Chinook salmon spawning and egg incubation in the upper Sacramento River. These months tend to have the warmest water temperatures for both the current operating scenario and proposed action ; in critical water years, temperatures consistently exceed the upper limit of the temperature-related critical habitat physical or biological feature for spawning, egg incubation, and fry development (i.e., 57.5°F).

9.1.1.2 Freshwater Rearing Habitat

Freshwater rearing habitat occurs for all three salmonid species in the mainstem Sacramento River downstream to the Delta. Neither the proposed action nor the current operating scenario are likely to affect contaminant levels or sources in the action area. Primary sources of contaminants in the Sacramento River are from non-point source runoff and drainages from agriculture and municipalities. While relative changes in the volume of flows influence contaminant sources, as flow can affect the concentration or dilution of contaminants, flows under the proposed action are generally similar to the current operating scenario and are unlikely to affect the concentration of contaminants entering the river.

The availability of freshwater riparian habitat that provides for successful juvenile development and survival is also affected by flow. Rearing weighted usable area analysis for Sacramento River segments 6 (Anderson-Cottonwood Irrigation District Dam to Keswick Dam) and 5 (Cow Creek to the Anderson-Cottonwood Irrigation District Dam) show varying degrees of habitat capacity but no discernable trend between the current operating scenario and proposed action . The exception is CV spring-run Chinook salmon and CCV steelhead rearing weighted usable area in the upper Sacramento River during the months of January and February when both species are beginning to emigrate. For those months, the rearing weighted usable area of the proposed action is somewhat less than the current operating scenario indicating a lower overall quality of available rearing habitat in the upper Sacramento River under the proposed action .

While weighted usable area provides a metric of habitat quality, an indicator of the available quantity of riparian habitat is floodplain inundation. Results of floodplain inundation analyses based on the mean monthly inundation for the upper, middle and lower Sacramento River as well as the bypasses (Sutter and Yolo) show a general trend across all locations that the differences in mean floodplain inundation is usually very small when comparing the current operating scenario to proposed action . For the upper, middle and lower Sacramento River, the amount of floodplain inundation is usually the same or greater under the proposed action from December through August, while the opposite is the case from September through November. Although the absolute differences are very small, the relative decrease in floodplain inundation during the September to

November timeframe is important for winter-run Chinook salmon because this is the period when the majority of juveniles are rearing in the river or migrating to the Delta. Inundation analysis for the Sutter and Yolo bypasses show very little difference between the current operating scenario and the proposed action . CalSimII results for Fremont Weir spill show a slight increase in the monthly flow on to the Yolo Bypass for the proposed action compared to the current operating scenario in November through March; this would provide a small increase in freshwater rearing habitat for all juvenile salmonids.

9.1.1.3 Migratory Corridors

A functioning migration corridor 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 upper river. Differences in modeled flows are small between the proposed action and current operating scenario, with the largest differences occurring in September and November when proposed action flows are significantly lower than the current operating scenario. The September to November period corresponds to the peak of winter-run Chinook salmon juvenile migration past Red Bluff Diversion Dam, so decreased river flow at this time would reduce the transport of winter-run Chinook salmon out of the upper river. The pulses are expected to provide improved migration corridor habitat conditions from March 1 to May 15 for CV spring-run Chinook salmon and CCV steelhead juveniles in years where a spring pulse flow is implemented.

Modeled water temperatures are generally adequate in the middle and upper Sacramento River for immigrating adult salmonids during the early portion of their respective migration periods. Starting in May and through the summer, temperatures in the middle reaches of the river begin to increase, and they can exceed temperatures that accommodate volitional migration and subsequently can impede adult upstream migration. During this period, conditions for the proposed action are slightly improved over the current operating scenario but could still pose an impediment to adult migration. These effects may be partially mitigated by the habitat restoration components of the proposed action which could provide improvement to temperatures in the freshwater migration corridor habitat. In particular, channel margin restoration and the spawning and rearing habitat enhancement projects could provide additional instream cover that would improve river conditions. However, these proposed action components have been proposed as programmatic actions and both the effects and the likelihood of implementation are uncertain.

Unscreened diversions in the Sacramento River also pose an impediment to migration since fish can be entrained into unscreened or poorly screened diversions. To address this issue, Reclamation has proposed a number of projects to screen diversions or modify existing screens in Sacramento River. Though these projects are expected to improve conditions in the migratory corridor habitat, the timing and extent of these projects is uncertain, and therefore we do not rely heavily on these improvements to reach our conclusion about effects to critical habitat. In addition to diversion screening, the proposed action would fund reconstruction of the Knights Landing Outfall Gates, which would reduce the potential for fish straying into and getting trapped in the Colusa Basin Drain. This would improve the function of physical and biological features of adult migratory corridor habitat in the lower Sacramento River.

9.1.2 Effects to Green Sturgeon Designated Critical Habitat

Critical habitat for the sDPS green sturgeon includes physical or biological features that describe features of habitat types for multiple life stages. Specific physical or biological features that are present in the action area are identified within each general habitat type and described in the context of each life stage.

9.1.2.1 Habitat for Spawning Adults, Incubation of Eggs, and Rearing for Larvae

- Water Quality
- Water Flow
- Substrate Type or Size

Spawning habitat occurs for sDPS green sturgeon in the upper reaches of the Sacramento River concentrated between Glenn Colusa Irrigation District/Hamilton City, upstream to Cottonwood Creek (see Section 2.2 Rangewide Status of the Species and Critical Habitat).

Water temperatures from Cold Water Pool Management in Shasta Reservoir will result in lower than optimum temperatures in a portion of the available spawning and rearing habitat in the Sacramento River and this will decrease the condition of the primary constituent element for water quality, especially in the upper reaches of the Sacramento River near the Anderson Cottonwood Irigation District Dam. Further downstream, the action has a diminished impact on water temperature. However, these areas will still support the function of the migratory corridor by providing connectivity between freshwater spawning and rearing habitat and the ocean.

Overall, the lethal threshold of 71.5°F for eggs and larvae is exceeded in less than 1 percent of days at Hamilton City (most downstream recorded spawning event), but the threshold for sublethal effects, 63.5°F, would be exceeded in 39 percent of days at Hamilton City. Actual temperature effects in sDPS green sturgeon critical habitat are expected to be less significant than modeled effects since spawning occurs in deep pools which are insulated from degradation of the spawning habitat water quality physical or biological feature. The water flow physical or biological feature of sDPS green sturgeon critical habitat is not expected to be negatively affected by the proposed action, since flows in the spawning region (Cottonwood Creek to Hamilton City) during the spawning period (April to July) are sufficient for spawning adults and rearing larvae.

The proposed action includes a number of proposed habitat restoration actions that could restore, add, or otherwise improve spawning gravel within the primary spawning range for green sturgeon in the Sacramento River. With regard to the substrate type or size physical or biological feature, channel margin restoration and the spawning and rearing habitat enhancement projects could provide additional sources of suitable spawning gravel that would improve river spawning conditions. However, because these proposed action components have been proposed as programmatic actions, the effects and likelihood of implementation are uncertain.

9.1.2.2 Freshwater Rearing Habitat

- Water Quality

- Water Flow
- Food Resources
- Sediment Quality
- Depth

Based on laboratory studies of northern DPS green sturgeon, optimal bioenergetic performance for juvenile green sturgeon (including growth, metabolic rate, temperature preference, and swimming performance) occurs at 59°F to 66°F (Mayfield and Cech 2004). 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 upper to middle Sacramento River for the proposed action may have a small adverse effect on the water quality critical habitat physical or biological feature used by juveniles for rearing.

The water flow physical or biological feature of sDPS green sturgeon critical habitat is also related to the food resources, sediment quality, and depth physical or biological features because water flow can determine access to the quantity and quality of the other physical or biological features 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 physical or biological features of food resources, sediment quality, and depth. For the upper, middle, and lower Sacramento River, the amount of floodplain inundation is usually the same or greater for the proposed action in December through August, while the opposite is the case in September through November. Inundation analysis for the Sutter and Yolo bypasses show very little difference between the current operating scenario and the proposed action . CalSimII results for Fremont Weir spill show a slight increase in the monthly flow on to the Yolo Bypass for the proposed action compared to the current operating scenario in November to March. This is expected to provide a small increase in freshwater rearing habitat for juvenile sDPS green sturgeon. Overall, the proposed action provides a sufficient flow regime that promotes the normal behavior, growth, and survival of all sDPS green sturgeon life stages.

9.1.2.3 Freshwater Migratory Corridors for Outmigrating Juveniles and Spawning Adults

- Migratory Corridor
- Sediment Quality
- Depth

Freshwater migratory corridors for sDPS green sturgeon are those migratory corridors linking estuarine habitat in the Delta with the spawning habitat in upstream spawning reaches of the Sacramento River. Unscreened diversions in the Sacramento River pose a potential impediment to migration since fish can be entrained into unscreened or poorly screened diversions. To address this issue, Reclamation has proposed projects to screen diversions or modify existing screens in Sacramento River. In addition, the proposed spring pulse flows should improve migratory corridor habitat function when the operation is implemented.

9.2 Trinity River Division

9.2.1 Effects to Salmonid Designated Critical Habitat

Clear Creek is designated critical habitat for CV spring-run Chinook salmon and CCV steelhead. The physical or biological features of designated critical habitat in Clear Creek include: (1)

freshwater spawning sites, (2) freshwater rearing sites, and (3) freshwater migration corridors. This analysis of effects of the proposed action on critical habitat is based on the species effects analysis in Section 2.5, and is summarized as they relate to the physical or biological features of critical habitat, in Table 135 for CV spring-run Chinook salmon and Table 136 for CCV steelhead. 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, response, risk), as the foundation for our analysis of effects to critical habitat. For example, as effects of riparian removal on rearing juveniles is likely to result in reduced growth/survival, the effect to critical habitat would be described in terms of the physical or biological features affected for that life stage, thereby resulting in degraded rearing habitat.

Table 135. Summary of probable change in physical or biological feature of Central Valley spring-run Chinook salmon designated critical habitat in Clear Creek.

Action Component	physical or biological features Affected	Response	Probable Change in physical or biological feature
Water temperature management: Fall	Fresh water spawning sites	Spawning temperature criterion (56°F) is suboptimal and exceedance further degrades spawning habitat. Greatest impact to habitat downstream of compliance point, and in Critical water year types.	Reduced quantity and quality of spawning habitat.
Minimum instream base flows	Fresh water spawning sites	Base flows provide suitable spawning habitat, but lack variation that provides habitat complexity. In Critical water year types, reduced base flows will degrade spawning habitat.	Reduced quantity and quality of spawning habitat.
Spring attraction pulse flows	Fresh water spawning sites	Pulse flows mobilize and disperse some spawning gravel, and decrease fines, which can improve spawning habitat.	Some increased quality and quantity of spawning habitat.
Channel maintenance pulse flows	Fresh water 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.	Some increased quality and quantity of spawning habitat. Continued degradation of spawning habitat because flows are not of magnitude to shape the channel.
Water temperature management: Summer	Fresh water rearing sites	Exceedance of water temperature criterion (60°F) downstream of compliance point degrades juvenile rearing habitat.	Reduced quality of rearing habitat.

Action Component	physical or biological features Affected	Response	Probable Change in physical or biological feature
Minimum instream base flows	Fresh water rearing sites	Lack of variability leads to reduced habitat complexity. In Critical years, reduced base flows and less rearing habitat.	Reduced quantity and quality rearing habitat.
Spring attraction pulse flows	Fresh water rearing sites	Pulse flows mobilize some gravel to form new habitat, and will temporarily increase rearing habitat availability.	Improved connectivity to rearing habitat temporarily.
Spring attraction pulse flows	Fresh water rearing sites	Ramp down following pulse flow create stranding habitat.	Degraded rearing habitat.
Channel maintenance pulse flows	Fresh water 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.	Improved connectivity and increase available rearing habitat temporarily. Continued degradation of rearing habitat because flows are not of magnitude to shape the channel.
Channel maintenance pulse flows	Fresh water rearing sites	Ramp down following pulse flow create stranding habitat.	Degraded rearing habitat.
Water temperature management: Summer	Freshwater migration corridors	Exceedance of water temperature criterion (60°F) downstream of compliance point degrades adult holding habitat.	Reduced quality of holding habitat in migratory corridor.
Water temperature management: Summer	Freshwater migration corridors	Warm water may block upstream adult migration, or juvenile emigration near confluence.	Degraded migratory corridor.
Water temperature management: Fall	Freshwater migration corridors	Decreased water temperatures may improve conditions for migration.	Improved migratory corridor for juveniles and adults.

Action Component	physical or biological features Affected	Response	Probable Change in physical or biological feature
Minimum instream base flows	Freshwater migration corridors	Flows may lack variability to create cues for juvenile emigration and adult migration, especially in Critical and Dry water year types.	Reduced quality of migration corridor.
Spring attraction pulse flows	Freshwater migration corridors	Pulse flows increase turbidity, decrease barriers, and increase passage routes.	Improved migratory corridor for adults and juveniles temporarily.
Channel maintenance pulse flows	Freshwater migration corridors	Pulse flows increase turbidity, decrease barriers, and increase passage routes.	Improved migratory corridor.

Table 136. Summary of responses of Clear Creek CCV steelhead to the proposed action and probable change in physical or biological feature of California Central Valley steelhead designated critical habitat in Clear Creek.

Action Component	physical or biological features Affected	Response	Probable Change in physical or biological feature
Minimum instream base flows	Fresh water spawning sites	Base flows provide suitable spawning habitat, but lack variation that provides habitat complexity. In Critical water year types, reduced base flows will degrade spawning habitat.	Reduced quantity and quality of spawning habitat.
Spring attraction pulse flows	Fresh water spawning sites	Pulse flows mobilize and disperse some spawning gravel, and decrease fines, which can improve spawning habitat.	Some increased quality and quantity of spawning habitat.
Channel maintenance pulse flows	Fresh water spawning sites	Pulse flows mobilize and disperse some spawning gravel, and decrease fines, which can improve spawning habitat. Magnitude and duration is not likely to be great enough to shape the channel and adequately route spawning gravel and improve spawning habitat.	Some increased quality and quantity of spawning habitat. Continued degradation of spawning habitat because flows are not of magnitude to shape the channel.

Action Component	physical or biological features Affected	Response	Probable Change in physical or biological feature
Water temperature management: Summer	Fresh water rearing sites	Warm water temperatures downstream of temperature compliance point degrade juvenile rearing habitat.	Reduced quality of rearing habitat
Minimum instream base flows	Fresh water rearing sites	Lack of flow variability leads to reduced habitat complexity. In Critical years, reduced base flows will reduce available rearing habitat.	Reduced quantity and quality rearing habitat
Spring attraction pulse flows	Fresh water rearing sites	Pulse flows mobilize and disperse some spawning gravel, and decrease fines, which can improve spawning habitat.	Some increased quality and quantity of spawning habitat.
Spring attraction pulse flows	Fresh water rearing sites	Ramp down following pulse flow create stranding habitat. Ramping rate will be used.	Degraded rearing habitat.
Channel maintenance pulse flows	Fresh water 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.	Improved connectivity and increased available rearing habitat temporarily. Continued degradation of rearing habitat because flows are not of magnitude to shape the channel.
Channel maintenance pulse flows	Fresh water rearing sites	Ramp down following pulse flow create stranding habitat. Ramping rate will be used.	Degraded rearing habitat.
Water temperature management: Summer	Freshwater migration corridors	Warm water may block adult migration near mouth.	Degraded migratory corridor.
Water temperature management: Fall	Freshwater migration corridors	Decreased temperatures may improve conditions for migration.	Improved migratory corridor for juveniles and adults.

Action Component	physical or biological features Affected	Response	Probable Change in physical or biological feature
Minimum instream base flows	Freshwater migration corridors	Flows may lack variability to create cues for juvenile emigration and adult migration, especially in Critical and Dry water year types.	Reduced quality of migration corridor.
Spring attraction pulse flows	Freshwater migration corridors	Pulse flows increase turbidity, decrease barriers, and increase passage routes.	Improved migratory corridor for adults and juveniles temporarily.
Channel maintenance pulse flows	Freshwater migration corridors	Pulse flows increase turbidity, decrease barriers, and increase passage routes	Improved migratory corridor temporarily.

9.2.1.1 Freshwater Spawning Sites

Water temperatures, water flow, loss of natural river morphology and function, loss of floodplain habitat, and physical habitat alteration, are baseline stressors that degrade the freshwater spawning habitat physical or biological features for adult CV spring-run Chinook salmon and CCV steelhead in Clear Creek. Some of these (water temperatures, flows and habitat conditions) are also project related stressors. Spawning habitat physical or biological features for CV spring-run Chinook salmon are affected by water temperatures because (1) the proposed action spawning temperature target (56°F) is suboptimal, (2) in some years, water temperatures are elevated above the spawning criteria, and (3) elevated water temperatures are higher and occur more frequently in spawning habitat downstream of the Igo gauge.

The proposed minimum instream base flows provide adequate habitat for spawning for CV spring-run Chinook salmon and CCV steelhead, based on the weighted usable area assessment (U.S. Fish and Wildlife Service 2015a; Unger 2019). However, lack of flow variation prohibits the creation of channel complexity, degrading spawning habitat over time. In Critical water year types, minimum instream base flows would be reduced, resulting in degradation of spawning habitat physical or biological features including CV spring-run Chinook salmon or CCV steelhead redd dewatering.

Under the proposed action, both spring attraction and channel maintenance, are expected to improve spawning habitat quality and quantity by mobilizing and dispersing gravel to some degree, and reducing fine sediment. Channel maintenance pulse flows under the proposed action will not occur in Critical and Dry water year types, and would not 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 (900 cfs). Therefore, channel maintenance pulse flows are expected to provide some improvement to the spawning habitat physical or biological feature. Although some benefits are expected in a low number of years, pulse flows are not expected to substantially benefit the freshwater spawning site physical or biological features 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.

9.2.1.2 Freshwater Rearing Habitat for Juveniles

Water temperatures, 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 physical or biological features for juvenile CV spring-run Chinook salmon and CCV steelhead in Clear Creek. The proposed action minimum instream base flows generally provide suitable water temperatures with constant, year-round flows that contain adequate access to rearing habitat. However, the proposed action base flows do not provide the complexity needed for preferable rearing habitat that provides access to floodplains and additional rearing habitat, which would lead to increased growth and provides refugia from predators.

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 physical or biological features, 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, resources for increased growth and survival. The pulse flows also result in degraded rearing habitat physical or biological features from stranding or isolating juveniles when flows are lowered, especially if no gradual ramp down methods are implemented. Down-ramping rates will be implemented, which will reduce stranding risk and minimize negative impacts on survival from flow decreases, and therefore we expected minor impacts to rearing habitat physical or biological features 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. Warmer temperatures in this rearing habitat is expected to increase the likelihood of predation by providing habitat more suitable for warm-water predatory fishes.

9.2.1.3 Freshwater Migratory Corridors for Outmigrating Juveniles and Spawning Adults

Water temperatures, water flow, loss of natural river morphology and function, loss of floodplain habitat, and physical habitat alteration are baseline stressors that degrade the freshwater migratory corridor physical or biological features 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 condition. Migratory habitat physical or biological features for adults and juveniles is expected to be 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 affect CV spring-run Chinook salmon holding habitat downstream of the Igo gauge. Flows will increase and water temperatures will decrease during the fall temperature management under the proposed action, improving the migratory corridor physical or biological features for both juvenile and adult CV spring-run Chinook salmon, and CCV steelhead.

Increased flow releases during pulse flows under current operations will provide flow variation, increased turbidity, cover, and additional passage routes. These conditions are expected to improve the freshwater migratory corridor physical or biological features for CV spring-run Chinook salmon adults and juveniles, and CV steelhead juveniles. Pulse flows for channel maintenance and spring attraction will continue to provide improvement to the migratory corridor.

9.3 American River Division

9.3.1 Effects to Steelhead Designated Critical Habitat

The lower American River is designated critical habitat for CCV steelhead. The physical or biological features 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 steelhead critical habitat is based on information presented in preceding sections regarding its effects to CCV steelhead, and are summarized below as they relate to the physical or biological features of critical habitat.

Although there is some improvement in the proposed action, spawning and rearing physical or biological features in the American River are still expected to be affected by flow and water temperature conditions associated with the proposed action, as they are under the current operations. Elevated water temperatures can affect spawning habitat for those CCV steelhead that spawn later in the season, or farther downstream, leading to reduced productivity. Consequently, reduced suitability of habitat due to elevated water temperatures during some months of the spawning season can result affect spawning physical or biological features for salmonid critical habitat.

Spawning and rearing habitat in the lower American River is affected by flow fluctuations, which can result in redd dewatering and isolation, fry stranding, and juvenile isolation (see Section 8.5.2.1).

Freshwater migration corridors also are physical or biological features of critical habitat. They are located downstream of spawning habitat, allow the upstream passage of adults and the downstream emigration of juveniles. Migratory habitat conditions for CCV steelhead smolt emigration are expected to be impaired with implementation of the proposed action, because of exposure to suboptimal water temperatures for smolt life stages.

9.4 Bay-Delta Division

Critical habitat impacted by the proposed action includes the waters of the Sacramento – San Joaquin Delta, which is generally defined as the legal Delta which roughly 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 I-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 exist in the Delta Division for the following species:

- Sacramento River winter-run Chinook salmon
- CV spring-run Chinook salmon
- CCV steelhead
- sDPS green sturgeon

9.4.1 Effects to Salmonid Designated Critical Habitat

Critical habitat for winter-run Chinook salmon exists in the main stem 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. Winter-run Chinook salmon critical habitat also includes the waters westward of Chipps Island to the Carquinez Bridge including Suisun Bay, Honker and Grizzly bays 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 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 main stem Sacramento from the I Street Bridge to the western tip of Sherman Island, and the waterways located to the north of the main stem Sacramento River, including Sutter, Steamboat, Miner, Elk, and Elkhorn sloughs, the Cache Slough complex, and the Yolo Bypass. Waterways to the south of the main stem Sacramento River that are designated as CV spring-run critical habitat include Georgiana Slough to its confluence with the Mokelumne River, Threemile Slough to its confluence with the San Joaquin River, and that 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 physical or biological features. The physical or biological features for 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 physical or biological features that correspond to ESA-listed critical habitat are identified.

The physical or biological features 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 are summarized below as they relate to the physical or biological features of critical habitat. .

9.4.1.1 Freshwater Rearing Habitat

Sacramento River winter-run Chinook salmon physical or biological features:

- Habitat areas and adequate prey that are not contaminated

- Riparian habitat that provides for successful juvenile development and survival

CV spring-run Chinook salmon and CCV steelhead physical or biological features:

- Fresh water 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, and most of it has been degraded by anthropogenic actions (i.e. levee construction, removal of riparian vegetation, and armoring of shorelines and levees).

Actions related to the proposed action include the construction 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 (~May – November). This can reduce dissolved oxygen through less mixing, and 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 favor non-native predators, such as centrarchids, as well as aquatic plants such as Brazilian waterweed (*Egeria densa*) and water hyacinth (*Eichhornia crassippes*). 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 potential to expand the period of water transfers to include October and November may enhance rearing conditions in both the northern and southern Delta by increasing flows and improving water quality. Increased flows during this period may improve water temperatures, as well as increasing 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 main stem rivers may also benefit primary and secondary production, which then enhances the forage base for listed salmonids. However, under the proposed action component to extend the water transfer window an additional 2 months, the potential to increase the level of exports to capture this water increases. Increased exports create conditions that diminish the value of the regional waterways as migratory corridors (see following discussion).

9.4.1.2 Freshwater Migratory Corridors

Sacramento River winter-run Chinook salmon physical or biological features:

- 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

CV spring-run Chinook salmon and CCV steelhead physical or biological features:

- 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 main stem 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 more frequently than the current operating scenario by opening the gates during the fall and early winter. As clarified in the final proposed action, the Delta Cross Channel openings during December and January will occur only during drought conditions when there are also water quality concerns that could be addressed by opening the Delta Cross Channel gates (see Section 8.6.3: *Delta Cross Channel Operations*). When the Delta Cross Channel gates are open, it allows for the routing of juvenile listed salmonids into the interior Delta where studies have shown survival to be lower for acoustic tagged study fish (Chinook salmon). Hydrodynamic modeling and studies using acoustic tagged Chinook salmon have also shown downstream effects when the gates are open that increases 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 (see section 2.5.6.2.4). 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. Migration upstream 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 main stem Sacramento River.

Alterations in flow, and the creation of migratory barriers are anticipated from the installation and operation of the south Delta agricultural barriers for both adult and juvenile 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. This will impact the functioning of the freshwater migratory corridors of the designated critical habitat for CCV steelhead in the south Delta. Delays in upstream migration of adult 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 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 exist.

There are aspects of the proposed action that may improve migratory corridor function, namely the extension of the water transfer window. Since transfers may originate from either the Sacramento River 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 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 (predominately steelhead due to the timing of the transfer window) increased flows should stimulate upstream migration into the upper rivers from the Delta as well as providing 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.

9.4.1.3 Estuarine Habitat for Rearing and Migration

Sacramento River winter-run Chinook salmon physical or biological features:

- 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

CV spring-run Chinook salmon and CCV steelhead physical or biological features:

- 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 zone in which fresh water 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 fresh water from rivers or streams. In fresh water the concentration of salts, or salinity, is nearly zero. The salinity of water in the ocean averages about 35 parts per thousand (ppt). The mixture of seawater and fresh water 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 micro Siemens 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 winter-run and spring-run Chinook salmon and CCV steelhead downstream from approximately Rio Vista to approximately 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 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 physical or biological features of critical habitat in only a few instances. 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 physical or biological features for winter-run Chinook salmon include "habitat areas and adequate prey that are not contaminated." Likewise, the physical or biological features for 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 meet these physical or biological features.

Listed winter-run Chinook salmon, CV spring-run Chinook salmon, and CCV steelhead could be affected by the operation of the Suisun Marsh Salinity Control Gates, 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 winter-run Chinook salmon, CV spring-run Chinook salmon, and CCV steelhead that do not continue upstream past the Suisun Marsh Salinity Control Gates 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 17 to 69 days of annual operation, which could also delay juvenile winter-run and CV spring-run Chinook salmon and CCV steelhead migration. However, these changes in water flow will be limited to the flood portion of the tidal cycle and will generally be limited to a few days during each periodic operational episode. Overall, the short-term changes to tidal flow patterns in Montezuma Slough due to operation of the Suisun Marsh Salinity Control Gates are expected to cause a minor impact to this physical or biological feature for both migrating juveniles and adults of these listed salmonids. The operations of the Suisun Marsh Salinity Control Gates may impact designated critical habitat estuarine physical or biological features for CCV steelhead or 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 Suisun Marsh Salinity Control Gates 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 winter-run as any changes to the habitat are not permanent and it is not expected that any adult or juvenile winter-run 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 are unlikely to be affected during the summer gate operations.

Studies of nutrient movement and food production are also proposed in the Delta that are expected to improve primary and secondary productivity, increasing the forage base for migrating juveniles. Some of these studies also involve operating gates or other obstructions that would impede passage, and could degrade water quality by introducing higher concentrations of nutrients and suspended sediments that would reduce dissolved oxygen. Reclamation and DWR propose to monitor for dissolved oxygen in Grizzly Bay when operating the Roaring River Distribution System for food subsidies. This monitoring would be intended to make sure the action does not cause hypoxia in fish, reducing the potential for degradation of water quality and habitat function within this migratory corridor in the Delta.

The proposed action also indicates that the remaining 6,000 acres of tidal habitat restoration in the Delta of the original 8,000 acres committed to by DWR will be completed under the proposed action. Construction of the tidal habitat restoration areas may create temporary conditions that degrade designated critical habitat for all three listed species in the estuarine areas. Reclamation has indicated in its biological assessment for the consultation (Reclamation 2019) that there may be:

> *"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 and 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."*

Such actions would temporarily degrade the functioning of the estuarine critical habitat for listed salmonids by reducing available forage base, introducing contaminants to the aquatic system, and interfering with unimpeded access for both juveniles and adults to move through the estuarine system. The scope of this effect is not currently certain, since the restoration project was not fully described, including all locations of restoration sites and the schedule for work to be completed. It is expected though, that in the future, the restored tidal habitat will be a net benefit and provide additional refuge and rearing habitat for juvenile listed salmonids, additional forage base, and better growth and survival for fish utilizing these habitats.

9.4.1.4 Summary of Effects to Salmonid Designated Critical Habitat

Table 137. Summary of probable change in physical or biological feature of Central Valley salmonids designated critical habitat in the Delta.

Action Component	physical or biological feature Affected	Species	Response	Probable Change in physical or biological feature
Water transfer window extension	Freshwater rearing sites	WRCS CV SRCS CCV SH	1) Improved in-river water flow may improve water temperature conditions in the mainstem Sacramento River. 2) Improved water flow may improve dissolved oxygen conditions through improved mixing of water column and water surface - air interface. 3) Improved water quality in fall may improve primary and secondary productivity benefitting forage base.	Improved quality of rearing habitat for WRCS, CV SRCS, and CCV SH
Water transfer window extension	Freshwater migratory corridor	WRCS CV SRCS CCV SH	Enhanced flows from water transfers can benefit juvenile listed salmonids in fall (October and November) 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 fall.	Improved quality of freshwater migratory habitat for WRCS, CV SRCS, and CCV SH
North Bay Aqueduct/ Barker Slough Pumping Plant	Freshwater migratory corridor	WRCS CV SRCS CCV SH	Operations of North Bay Aqueduct/ Barker Slough Pumping Plant may delay migration of juveniles due to alterations to flow patterns created by the export of water and thereby inhibiting the mobility of juvenile listed salmonids and reducing their survival.	Reduced quality of migratory habitat for juveniles.

Action Component	**physical or biological feature Affected**	**Species**	**Response**	**Probable Change in physical or biological feature**
Delta Cross Channel Gate Operations	Freshwater migratory corridor	WRCS CV SRCS CCV SH	1) Access to the interior Delta through open Delta Cross Channel gates reduces the survival of migrating juveniles, reduces 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 allows access to habitat under the influence of the SWP and CVP export actions.	Reduced quality of migratory habitat for adults and juveniles; lesser effect in final proposed action due to revised Delta Cross Channel operations in December-January.
Contra Costa Water District/ Rock Slough	Freshwater migratory corridor	CCV SH	Operations of Contra Costa Water District/ Rock Slough may delay migration of juveniles due to alterations to flow patterns created by the export of water and thereby inhibiting the mobility of juvenile listed salmonids and reducing their survival.	Reduced quality of migratory habitat for juveniles.
CVP and SWP Export Facilities	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 steelhead migration downstream to the ocean (reverse flows),	Reduced quality of migratory habitat for juveniles, lesser effect in final proposed action due to revised loss thresholds.
South Delta Agricultural Barriers	Freshwater rearing sites	CCV SH	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.	Reduced quality of rearing habitat for juveniles

Action Component	physical or biological feature Affected	Species	Response	Probable Change in physical or biological feature
South Delta Agricultural Barriers	Freshwater migratory corridor	CCV SH	Construction of the South Delta agricultural barriers create 1) barriers to the downstream movement of juvenile steelhead and upstream movement of adult steelhead into the San Joaquin River basin; 2) decreases in water quality, including lower dissolved oxygen and suitable water temperatures that impair physiology; 3) creates habitat with excessive predation risk.	Reduced quality of migratory habitat for juveniles and adult CCV SH.
Fall Delta Smelt Habitat	Freshwater rearing sites	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.	Minor enhancement of quality of rearing habitat
Fall Delta Smelt Habitat	Freshwater migratory corridor	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	Minor enhancement of quality of migratory corridor habitat
Fall Delta Smelt Habitat	Estuarine areas	WRCS, CV SRCS, CCV SH	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 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 and potentially create predator habitat.	Minor benefit for water quality improvement and forage base, minor deficit for obstruction of passage and enhanced predator risks for estuarine areas.

Action Component	physical or biological feature Affected	Species	Response	Probable Change in physical or biological feature
Sacramento Deep Water Ship Channel Food Study	Freshwater migratory Corridor	WRCS, CV SRCS, CCV SH	Potential improvement of primary and secondary productivity in Sacramento River downstream of the artificial DWSC. Possible resuspension of contaminated sediments. Migratory blockage created by closed gate.	Minor benefit for improved forage base, minor deficit for contaminants in the water body, migratory obstructions reducing quality of the migratory corridor.
North Delta Food Subsidies / Colusa Basin Drain Food Subsidy Studies	Freshwater migratory corridors	WRCS, CV SRCS, CCV SH	Potential degradation of water quality due to contaminants and nutrients related to agricultural practices that impact adult and juvenile mobility and survival. Potential benefit to primary and secondary productivity that enhances forage base, improving physiological status, survival, and mobility	Minor benefit for improved forage base, minor deficit for contaminants and nutrients in the quality of the migratory corridor.
Suisun Marsh Roaring River Distribution System Food Subsidy Studies	Estuarine areas	WRCS, CV SRCS, CCV SH	Temporary migratory obstructions due to Suisun Marsh Salinity Control Gates operations. Increase in juvenile and adult forage base due to nutrient infusions, resulting in growth and maturation	Minor deficit due to migratory obstructions and minor benefit due to enhanced forage prey base in the estuarine areas.
Tidal Habitat Restoration	Estuarine areas	WRCS, CV SRCS, CCV SH	Temporary degradation of water quality due to restoration construction actions. Temporary physical and behavioral disturbances creating migratory obstructions. Long term improvement in water quality, holding and rearing areas, forage base, and better growth and survival.	Early degradation of estuarine habitat due to restoration activities, followed by potential large improvements in estuarine habitat quality.

9.4.2 Effects to Green Sturgeon Designated Critical Habitat

Members of the sDPS green sturgeon population utilize the aquatic habitat of the Delta for rearing, resting and 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.

9.4.2.1 Freshwater Riverine Systems

The following physical or biological features 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 construction 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 (~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 is unlikely to be suitable for 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 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 main stem 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 main stem 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 back track 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 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 Clifton Court Forebay 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 Clifton Court Forebay 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 physical or biological features is considered medium due to the distribution of sDPS green sturgeon in the Delta. Furthermore, the final proposed action has loss thresholds for listed salmonids that have the potential to reduce exports if exceeded, thus reducing the potential magnitude of hydrodynamic effects in channels leading to the export facilities when implemented.

There are several actions related to the proposed action that occur within the SWP and CVP facilities or Clifton Court Forebay that could affect sDPS green sturgeon directly or the aquatic habitat they are found in; such as aquatic weed control or predator removal actions. However, these areas are outside the limits of designated critical habitat for sDPS green sturgeon and will not be discussed further.

9.4.2.2 Estuarine Systems

The following physical or biological features 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 water with salinities ranging from 0.5 ppt to full sea water 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 slough and channels up to the mean higher high tide line in those waterbodies.

Few actions described for the proposed action will impact estuarine critical habitat physical or biological features 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 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 as well as 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 Suisun Marsh Salinity Control Gates, with the gates potentially delaying upstream-migrating adult green sturgeon that have entered the Montezuma Slough migratory route and are seeking to exit the slough at its eastward end. Adult green sturgeon that do not continue upstream past the Suisun Marsh Salinity Control Gates 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 Suisun Marsh Salinity Control Gates operations.

However, any fish that is blocked or impeded from using this route can easily access Suisun Bay through the main stem 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 6,000 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 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.

9.4.2.3 Summary of Effects to sDPS Green Sturgeon Critical Habitat

Table 138. Summary of probable change in physical or biological feature of Southern Distinct Population Segment green sturgeon designated critical habitat in the Delta.

Action Component	physical or biological feature Affected	Response	Probable Change in physical or biological feature
Water transfer window extension	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.	Improved quality habitat of freshwater riverine habitat for water quality, migration and 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 sDPS green sturgeon.	Minimal reduced quality of migratory corridor for juveniles.

Action Component	physical or biological feature Affected	Response	Probable Change in physical or biological feature
Delta Cross Channel Gate Operations	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, enhances straying and migratory delays. 4) Open Delta Cross Channel gates allows access to habitat under the influence of the SWP and CVP export actions.	Reduced quality of migratory habitat for adults and juveniles; lesser effect in final proposed action due to revised Delta Cross Channel operations in December-January.
Contra Costa Water District/ Rock Slough	Freshwater Riverine Habitat	Operations of Contra Costa Water District/ Rock Slough may alter the movements of juveniles due to alterations to flow patterns created by the export of water and thereby impeding the mobility of juvenile sDPS green sturgeon.	Reduced quality of migratory habitat for juveniles.
CVP and SWP Export Facilities	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 sDPS green sturgeon movements in the region's migratory corridors (reverse flows),	Reduced quality of migratory habitat for juveniles, lesser effect in final proposed action due to revised loss thresholds.

Action Component	**physical or biological feature Affected**	**Response**	**Probable Change in physical or biological feature**
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 sDPS green sturgeon within the South Delta waterways containing the barriers;	Reduced quality of freshwater riverine habitat for water flow, water quality, and as a migratory corridor
Fall Delta Smelt Habitat	Freshwater Riverine Habitat	Release of additional water from upstream to augment Delta outflow will improve water quality, and enhance forage prey populations that support juvenile and adult sturgeon. Release of additional water from upstream to augment Delta outflow will improve water flow supporting the mobility and survival of adult and juvenile sDPS green sturgeon	Minor enhancement in the quality of the freshwater riverine habitat
Fall Delta Smelt Habitat	Estuarine areas	Release of upstream water will enhance 1) water quality, 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.	Minor benefit for water quality improvement and forage base, minor deficit for obstruction of passage for estuarine areas.
Sacramento Deep Water Ship Channel Food Study	Freshwater Riverine Habitat	Potential improvement of primary and secondary productivity in Sacramento River downstream of the artificial DWSC. Possible resuspension of contaminated sediments entering downstream areas designated as critical habitat for sDPS green sturgeon. Migratory blockage created by closed boat lock gate after periods of access through an open gate (upstream migrants cued by false attraction flows).	Minor benefit for improved forage base, minor deficit for contaminants in the water body, migratory obstructions reducing quality of the migratory corridor.

Action Component	physical or biological feature Affected	Response	Probable Change in physical or biological feature
North Delta Food Subsidies / Colusa Basin Drain Food Subsidy Studies	Freshwater Riverine Habitat	Potential degradation of water quality due to contaminants and nutrients related to agricultural practices that impact adult and juvenile mobility and survival. Potential benefit to primary and secondary productivity that enhances forage base, improving physiological status, survival, and mobility.	Minor benefit for improved forage base, minor deficit for contaminants and nutrients in the quality of the freshwater riverine habitat.
Suisun Marsh Roaring River Distribution System Food Subsidy Studies	Estuarine areas	Temporary migratory obstructions due to Suisun Marsh Salinity Control Gates operations. Increase in juvenile and adult forage base due to nutrient infusions, resulting in growth and maturation	Minor deficit due to migratory obstructions and minor benefit due to enhanced forage prey base in the estuarine areas.
Tidal Habitat Restoration	Estuarine areas	Temporary degradation of water quality due to restoration construction actions. Temporary physical and behavioral disturbances creating migratory obstructions. Long term improvement in water quality, holding and rearing areas, forage base, and better growth and survival.	Early degradation of estuarine habitat due to restoration activities, followed by potential large improvements in estuarine habitat quality.

9.5 Stanislaus River

The only 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.

9.5.1 Effects to Salmonid Designated Critical Habitat

CCV steelhead spawning habitat on the Stanislaus River is affected by East Side Division operations in two key categories: (1) flow releases may not maintain appropriate temperatures for spawning and egg incubation, particularly in April and May, and (2) flow releases do not support geomorphic processes that would remove fine sediment from spawning gravels and maintain interstitial flows to attract spawners and allow egg incubation. Monthly average water temperatures at Orange Blossom Bridge exceed the EPA -recommended criterion for CCV steelhead spawning and egg incubation (55°F) in the warmest 20 percent of years in March and April, 40 percent of years in May, and 80 percent of years in June. In general these are baseline conditions that would continue under the proposed action. However, proposed spring pulse flows and habitat restoration actions are expected to improve spawning habitat compared to current conditions. The conservation measure committing to 4,500 tons of gravel augmentation per year, to the extent achieved, will also help to replenish spawning gravels in the system.

9.5.1.1 Freshwater Rearing Habitat for Juveniles

The freshwater rearing sites physical or biological feature includes water quantity and floodplain connectivity to support juvenile growth and mobility, and water quality and forage to support juvenile development.

The conservation measure committing to 4,500 tons of gravel augmentation per year, to the extent achieved, will help to support rearing in the system, as young salmon and young and yearling trout are found in significantly higher densities in sites where gravel has been placed in the river to create riffle habitat.

The conservation measure committing to 50 acres of rearing habitat adjacent to the Stanislaus River by 2030, to the extent achieved, will help to augment rearing opportunities in the system.

9.5.1.2 Freshwater Migratory Corridors for Outmigrating Juveniles and Spawning Adults

Under proposed operations, the freshwater migration corridors on the Stanislaus River will continue to require juvenile CCV steelhead to pass water temperatures that may be lethal or sublethal.

The conservation measure committing to 50 acres of rearing habitat adjacent to the Stanislaus River by 2030, to the extent achieved, will help to provide diversified habitats along the Stanislaus River for migrating CCV steelhead.

9.6 San Joaquin River (East Side Division)

Consistent with Section 8.7.2 in the Effects to Species, 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.

9.6.1 Effects to Steelhead Designated Critical Habitat

The only designated critical habitat for ESA-listed salmonids in the San Joaquin River upstream of Mossdale to the confluence with the Stanislaus River is for CCV steelhead.

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 below as they relate to the physical or biological features of critical habitat.

9.6.1.1 Freshwater Rearing Habitat for Juveniles

Continued 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 this degradation of rearing habitat conditions.

9.6.1.2 Freshwater Migratory Corridors for Outmigrating Juveniles and Spawning Adults

Continued operations under the proposed action will generate temperatures in migration corridors in the San Joaquin River that are warmer than suitable for juvenile life stages, particularly in May and June. Flow management operations will continue to result in lower spring flows compared to a natural hydrograph, and this is expected to continue to increase migration travel times and residence times in the Delta, reducing the function of these areas as migration corridors consistent with current conditions.

9.6.2 Effects to Green Sturgeon Designated Critical Habitat

Southern DPS green sturgeon are known to occasionally be present in this stretch of the San Joaquin River. 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 in the context of 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 9.6.1.1 and Section 9.6.1.2. In brief, springtime flows and warm water temperatures will continue under the proposed action and is expected to degrade the value of the habitat with respect to the following physical or biological features: food resources, water flow and water quality, and migratory corridor, for the conservation of the species.

10 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 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.

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 vs. cumulative effects. Therefore, all relevant future climate-related environmental conditions in the action area are described in the environmental baseline.

10.1 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. 2014). 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 and their tributaries, and in the Delta, remain unscreened (CalFish 2019). The impacts from unscreened water diversions have improved due to the anadromous fish screen program, part of Central Valley Project Improvement Act, 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).

10.2 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.

Salmonid 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 1998; Scholz et al. 2012; Scott and Sloman 2004; Whitehead et al. 2004). Agricultural operations occurring 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 implementation of best management practices designed to be protective of 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.

10.3 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 Sacramento Regional Wastewater Treatment Plan, in order to comply with Order no. R5-2013-0124, has begun implementing compliance measures to reduce ammonia discharges. Construction of treatment facilities for three of the major projects required for ammonia and nitrate reduction was initiated in March 2015 (Sacramento Regional County Sanitation District 2015). Order no. R5-2013-0124, which was modified on October 4, 2013, by the Central Valley Regional Water Quality Control Board imposed new interim and final effluent limitations, which must be met by May 11, 2021 (Central Valley Regional Water Quality Control Board (CVRWQCB) 2013). By May 11, 2021, the Sacramento Regional Wastewater Treatment Plan must meet effluent limits 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 treatment plant is currently releasing several tons of ammonia in the Sacramento River each day.

The Environmental Protection Agency 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 (Connon et al. 2011; Eddy 2005). The ammonia exposure concentrations in these studies may be higher than environmental levels following dilution and downstream movement of Sacramento Regional Wastewater Treatment Plan discharge.

Werner et al. (2008), Werner et al. (2009), and Werner et al. (2010) analyzed the acute effects of Sacramento Regional Wastewater Treatment Plan effluence on delta smelt, rainbow trout, and flathead minnow. Specifically, these studies used 96-hour and 7-day lethal (acute exposure) concentrations as endpoints. The studies found that at ammonia/um concentrations reported downstream of the Sacramento Regional Wastewater Treatment Plan discharge, on average below 1 milligrams 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) were much higher than ammonia concentrations reported in environmental sampling. However, the Werner et al. (2008), Werner et al. (2009), and Werner et al. (2010) studies did not assess sublethal toxicity. Sublethal ammonia toxicity at concentrations similar to what have been reported downstream of Sacramento Regional Wastewater Treatment Plan (less than 1 milligrams per liter) has been demonstrated in fish (Wicks et al. 2002). Therefore, it is not unreasonable to assume that there may be sublethal effects of ammonia effluence on ESA-listed species in the area. 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 is 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 Plan are of concern with respect to chronic toxicity to delta smelt and other sensitive species."

10.4 Increased Urbanization

From 2016 to 2060, California's population is projected to grow by 30 percent: from 39.4 million to 51.1 million (0.6 percent annually), which will likely be accompanied by increases in urbanization and housing developments (California Department of Finance 2017). The Delta, East Bay, and Sacramento regions include portions of Contra Costa, Alameda, Sacramento, San Joaquin, Solano, Stanislaus, and Yolo counties, which are expected to increase in population by nearly three million people by the year 2060 (California Department of Finance 2017). Growth projections through 2050 indicate that all counties overlapping the Delta are projected to grow at a faster rate than the state as a whole (Delta Protection Commission 2012). 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 and highways, and public utilities.

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 and highways, and public utilities. Some of these actions, particularly those which are 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 1998; Scholz et al. 2012; Scott and Sloman 2004; Whitehead et al. 2004).

10.5 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 potentially will degrade riparian and wetland habitat 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. This, 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.

10.6 Changes in Non-Central Valley Project or State Water Project Diversions

Changes in location, volume, timing, and method of delivery 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 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 have information on the specific impacts from these programs to listed fish species or critical habitat at this time; 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 effects discussed in this opinion for similar habitat restoration activities. In general, NMFS expects that implementation of these programs will improve habitat conditions for listed fish into the future through the increased availability of instream flows and habitat restoration.

10.7 Activities within the Nearshore Pacific Ocean

Future tribal, state, and local government actions could occur in the form of 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, green sturgeon, and Southern Residents, 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 SRKW, 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.

10.8 Other Activities

Other future, non-Federal actions within the action area include: the dumping of domestic and industrial garbage 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 State Water Resources Control Board 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 2010b; State Water Resources Control Board 2017a). Since this policy was adopted, several power-generating units have been retired or repowered (Statewide Advisory Committee 2019). 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 2019).

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 resources and environmental baseline sections.

11 INTEGRATION AND SYNTHESIS

The Integration and Synthesis section 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 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 biological opinion, NMFS uses the VSP parameters of abundance, productivity, spatial structure, and diversity as surrogates for “reproduction, numbers, or distribution.”

Reclamation’s Without Action Scenario and the Environmental Baseline

Reclamation established a “without-action” scenario as part of the Environmental Baseline in their Biological Assessment to isolate and define potential effects of the proposed action apart from effects of non-proposed action. NMFS considers the without-action scenario to represent effects related to the existence of CVP and SWP facilities. The without-action scenario provides context for how these facilities have shaped the habitat conditions for species and critical habitat in the action area. Under Reclamation's "without action" scenario, there would be both positive and negative effects on the status of the species considered in this Opinion. Higher flows in winter and spring could have both positive and negative effects on salmonids. Benefits of higher flows include lower water temperatures, increased dissolved oxygen, increased habitat complexity, more rearing habitat, more refuge habitat, increased availability of prey, less predation risk, less entrainment risk, lower potential for pathogens and disease, lower concentrations of toxic contaminants, and emigration cues. Reduced flows during dry summer and fall months would have negative impacts on spawning adults, eggs, and alevin, and on rearing juvenile salmonids, resulting in increased temperature-dependent mortality of eggs, reduced juvenile growth rate and higher mortality of the juveniles, and a reduced population abundance.

Prior to the construction of Shasta Dam winter-run Chinook salmon persisted through prolonged droughts by spawning in the high elevation, cold water spring-fed rivers. These higher elevation habitats have been inaccessible to salmon since the late 1930s when construction of Shasta Dam was started. Under "without-action" scenario conditions, there would no Shasta and Keswick reservoir operations to control storage or releases, and no transfer of water from the Trinity River Basin. Therefore, there would be no control of flow or water temperature in the upper Sacramento River, where Sacramento River winter-run Chinook salmon spawn. Under these conditions, water temperatures would likely be much higher and intolerable in the summer spawning and egg incubation period, and river flows would be higher during January through May, affording better water quality including cooler water temperatures and higher dissolved oxygen.

For CV spring-run Chinook salmon, elevated fall temperatures in the upper Sacramento River would not be suitable CV spring-run Chinook salmon because water temperatures during the spawning and incubation period would generally be above thresholds for spawning adults and incubating eggs and alevins. ”Without-action” scenario monthly flows during February would be similar to the proposed action, but flows during March, April, and May would be higher in wetter years and would benefit outmigrating juveniles and holding adults.

For CCV steelhead, lower summer and fall flows would have negative impacts to juvenile rearing from decrease habitat availability and increased water temperatures. In contrast, increased winter and spring flows would likely have both negative and beneficial effects. The beneficial effects include; increase floodplain and side-channel habitat, increase foraging conditions, reduce competition and predation, lower water temperatures and higher dissolved oxygen. Negative effects would be expected from reduced habitat availability for spawning due to excessive depths, increased velocities and bed scour impacting redds.

For sDPS green sturgeon, flows would be higher during the period spawning period and could negatively affecting spawning habitat, water velocities, dissolved oxygen and water depth, which could reduce spawning success. Higher flows in the Delta could potentially increase water and sediment quality by flushing contaminated sediments downstream. During the summer months low flows would reduce the diversity of depths for shelter and migration of juvenile, sub-adult, and adult green sturgeon.

The Environmental Baseline also includes the effects of past and current operations of the CVP and SWP, and the additional effects of habitat restoration, predation from invasives, water quality, and other effects on species from Federal, State, and private actions to inform the current condition of winter-run Chinook salmon.

11.1 Sacramento River Winter-run Chinook Salmon Effects on the Species

The Sacramento River winter-run Chinook Salmon ESU was first listed as threatened in 1989 under an emergency rule. In 1994, NMFS reclassified the ESU as an endangered species. This ESU is also listed as "endangered" under the State of California's endangered species law (California Endangered Species Act or CESA). Currently, there is only one population, spawning downstream of Keswick Dam, making this species particularly vulnerable to environmental pressures. This vulnerability manifested during the recent drought when warm water releases from Shasta Reservoir contributed to egg-to-fry mortality rates of 85 percent in 2013, 94 percent in 2014, and 96 percent in 2015, the highest levels since estimates of that statistic began in 1996. Mortality decreased after the drought ended (76 percent and 56 percent mortality in 2016 and 2017, respectively), but the recovery criteria for this species, the Central Valley Salmon and Steelhead Recovery Plan (National Marine Fisheries Service 2014b), includes re-establishing populations into historical habitats in Battle Creek and upstream of Shasta Dam to reduce extinction risk due to compromised spatial structure.

The progeny of a captive broodstock from LSNFH were reintroduced to Battle Creek in 2017 and 2018 (U.S. Fish and Wildlife Service 2018b). This "Jumpstart Project" is expected to continue until a "Transition Plan" is developed that merges the Jumpstart Project with the Reinitiation Plan (U.S. Fish and Wildlife Service 2018b). The watershed currently has limited capacity to support a winter-run Chinook salmon population due to effects of a non-federal hydropower facility on habitat quantity and quality. However, Reclamation proposes a commitment of $14 million over ten years to accelerate the implementation of the Battle Creek Salmon and Steelhead Restoration Project. This project and Reclamation's commitment are expected to reestablish approximately 42 miles of prime salmon and steelhead habitat on the creek and another 6 miles on its tributaries. NMFS expects that this effort will support a second spawning population, improving the spatial structure of the ESU as anticipated in the recovery plan.

11.1.1 Temperature Management and Performance Metrics

The winter-run Chinook salmon population in mainstem Sacramento River population persists mainly because 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. Reclamation therefore proposes to provide protective water temperatures for during the May through October incubation period through a four-tiered operations strategy that is described and analyzed in detail in *Section 8.3.6.1, Upper Sacramento/Shasta Division, Summer Cold Water Pool Management*. An important part of the temperature management strategy is that Reclamation is proposing to operate to the most protective tier possible and to stay within a tier except in the event io f an emergency due to an unforeseen condition.

NMFS estimates that in Tier 1 years, Reclamation's management of Shasta's cold water pool will support an average modeled temperature dependent egg survival of 94-95 percent; which is expected to occur in 68 percent of years. In Tier 2 and 3 years, average modeled temperature dependent egg survival is 85-88 percent and 66-72 percent, respectively; which is expected to occur in 17 and 7 percent of years. In Tier 4 years, when the cold water pool is most limited, average modeled temperature dependent survival would range from 19-21 percent, which is expected to occur in 7 percent of years. Reclamation proposes to use the Upper Sacramento Performance Metrics to assess cold water temperature management of the four tiers. The objective is to operate with the full range of the measures with the expectation that results will range around the modeled averages as modeled.

Part of proposed temperature management strategy includes independent panel reviews. In January of 2024 and January of 2028, Reclamation will charter an independent panel to review whether there is a tendency or trajectory that will not lead to matching or exceeding the distribution of the modeled results over the long-term. Reclamation may also charter an independent panel review if the actual temperature dependent mortality or egg to fry survival fall outside the range described above in any single year. The panel would be charged with reviewing the drivers behind the management of cold water within the tiers; reviewing the performance objectives, including the methods for determining temperature dependent mortality and methods for determining total survival; reviewing the Tier types that have occurred during the performance periods of the Proposed Action and the performance within each tier as compared to expected performance; and recommending potential modifications to CVP operations that would improve cold water management and are within the agencies' authorities.

Reclamation also proposes performance metrics for total egg to fry survival measured at Red Bluff Diversion Dam. The 75th percentile values of the historical egg to fry survival will be used as a surrogate for expected improvements in egg to fry survival for each tier from the habitat restoration projects recently completed, underway, or proposed for completion within the proposed action. These egg to fry survival values are: Tier 1 – 32 percent and Tiers 2/3 – 27 percent. These measures are included to help track the performance of temperature management and upstream habitat restoration actions proposed as Collaborative Planning action components. If there are two consecutive years of low survival (below 15 percent), Reclamation, through the Sacramento River Temperature Task Group will identify and Reclamation will implement additional actions to protect eggs and fry. NMFS expects that such actions would be similar to the proposed Tier 4 intervention measures or actions that are developed for the Drought and Dry Year Actions toolkit.

During drier water years with operational conditions that match Tier 3 and Tier 4 scenarios, the SRS Contractors will meet and confer with Reclamation, NMFS, and other agencies as appropriate to determine if there is a 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 and would also lead to the desired outcome. The commitment from the SRS Contractors to meet and confer during Tier 3 and Tier 4 years may further decrease the uncertainty associated with high mortality values modeled for Tier 3 and Tier 4 years. NMFS expects that any actions taken could increase the likelihood that resulting mortality values would be minimized and may also help build storage in Shasta Reservoir. Although SRS Contractor 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 that will benefit the productivity and abundance of Sacramento River winter-run Chinook salmon.

11.1.2 Fall and Winter Reservoir Flows and Reservoir Management

Another important component of the proposed action is fall and winter refill at Shasta Reservoir to increase the likelihood that cold water will be available for redd maintenance the following year. This would be accomplished by reducing fall and winter outflow to refill Shasta Reservoir. Since water temperature is a very highly ranked threat to Sacramento winter-run Chinook salmon, as described in the NMFS recovery plan (National Marine Fisheries Service 2014b), actions that address this threat are very important to reduce the potential adverse effects of summer water temperatures. These 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 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.

11.1.3 Delta Cross Channel

The third important component of the proposed action that would affect the survival of winter-run Chinook salmon is the potential increase in routing through the Delta Cross Channel compared to a modeled Current Operations Scenario. Under these conditions, the proposed fall and winter flow reductions to refill the cold water pool in Lake Shasta would cause Reclamation to open the Delta Cross Channel gates more frequently during October and November. However, Reclamation would continue to use real time information (Knights Landing and Sacramento River Catch Indices) to close the gates, limiting the likelihood of juvenile Chinook entrainment into the Delta Cross Channel and thereby into the interior Delta. This would protect the survival of emigrating juvenile Chinook from the mainstem Sacramento and Battle Creek spawning populations.

11.1.4 Delta Performance Objectives and Old and Middle River Management

The last major component of the proposed action that would affect winter-run Chinook salmon is the action of pumping water from the south Delta export facilities and the associated effects of the fish salvage operations. As discussed in the Environmental Baseline section, there is wide recognition that the baseline condition is such that Delta flows and resulting effects on aquatic habitats do not support native fishes (including winter-run Chinook salmon) and that south Delta exports have played an important role in establishing that condition (California Department of Fish and Game 2010b; Hanak et al. 2011; National Marine Fisheries Service 2014b; State Water Resources Control Board 2017b; State Water Resources Control Board and California Environmental Protection Agency 2010). Reclamation proposes to increase south Delta water exports relative to a current operations scenario and results from the Salvage Density Model indicate that losses of winter-run Chinook salmon would increase under the proposed action (U.S. Bureau of Reclamation 2019c; Table 2.8.1-5). In addition, the loss estimates presented in Table 2.8.1-5 do not include loss due to louver cleaning, predation observed to occur on the upstream side of the trash racks (Vogel 2010), or far-field predation associated with altered hydrodynamics, and therefore underestimate mortality associated with south Delta pumping and fish salvage operations.

Based on the estimate of increased losses from the Salvage Density Model, Reclamation revised its proposed action with Additional Real-time Old and Middle Rivers Restrictions and Performance Objectives including a Cumulative Loss Threshold and a Single-year Loss Threshold. Both of these thresholds are based on observed losses during 2010-2018. If at any time before 2024, loss at the export facilities exceeds 50 percent of the cumulative loss threshold, Reclamation and the state Department of Water Resources will convene an independent panel to review the actions contributing to the loss trajectory and recommend modifications or additional actions to stay within the cumulative loss threshold. Regardless of the trajectory, Reclamation and DWR will convene the independent panel in the year 2024 to review observations over the past five years of the action and determine whether continuing actions will reliably maintain or improve the trajectory for the duration of the consultation period.

In addition, Reclamation and DWR propose to take actions to avoid exceeding an annual loss threshold equal to 90 percent of the greatest loss that occurred during 2010-2018. If 50 percent of a single-year threshold is exceeded, they will reduce the magnitude of reverse flows through the Old and Middle Rivers to a 14-day moving average of -3,500 cfs unless real-time fish monitoring data shows that the risk is no longer present. If 75 percent of the threshold is exceeded, reverse flows will be reduced to -2,500 cfs, for the remainder of the export season unless the real-time fish monitoring data shows that the risk is no longer present. Similar to the cumulative loss objectives, if the single-year loss threshold is exceeded, an independent panel will be convened to evaluate the efficacy of the actions taken to reduce effects to listed fish species and will provide recommendations for actions to reduce effects in following years.

NMFS expects that reducing the magnitude of reverse flows in the Old and Middle Rivers, if triggered by exceedances of the cumulative and annual loss thresholds, will improve the survival of juvenile Sacramento River winter-run Chinook salmon as they move through the Delta.

11.1.5 Conservation Measures

Reclamation proposes several conservation measures to improve the survival of the affected life stages of Sacramento winter-run Chinook salmon. The most significant actions include:

- Battle Creek Winter-run Chinook Salmon Reintroduction Plan and Battle Creek Salmon and Steelhead Restoration Project
- Spawning and Rearing Habitat Restoration
- Winter-run Chinook Salmon Conservation Hatchery Production and Tier 4 Intervention Measures
- Small fish screen program
- Knights Landing Outfall Gates
- Spring Management of Spawning Locations
- Temperature Modeling Platform
- Shasta Temperature Control Device Evaluations
- Tidal Habitat Restoration
- Predator Hot-spot Removal
- SRS Contractors Salmon Recovery Program

NMFS expects these conservation measures to offset adverse effects of the proposed action on winter-run Chinook salmon by further increasing the survival of juveniles and adults in spawning, incubation, rearing, and migration habitat throughout the Sacramento River and Delta. In particular, the pace of Sacramento River habitat restoration has been high in recent years with multiple projects completed annually through a strong partnership among the Northern California Water Association, the Western Shasta Resource Conservation District, the Sacramento River Forum, Chico State University, local landowners, and the five agency family of CDFW, DWR, NMFS, FWS, and Reclamation.

11.1.6 Climate Change Considerations

As previously described in this Opinion, Sacramento River winter-run Chinook salmon egg and fry stages are vulnerable to warmer water temperatures during the summer, so this run is particularly at risk from warming conditions due to climate change. The only remaining population of Sacramento River 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.

Reclamation’s proposed action includes components that will help buffer Sacramento River winter-run Chinook salmon from the effects of climate change including the 4-tiered water temperature management strategy for Shasta Reservoir operations; the use of independent panel reviews to evaluate tier performance and recommend operational adjustments to maintain or improve performance; and intervention measures and drought plans that are intended to proactively address drought conditions. Reclamation’s investment in habitat restoration and implementation of the Battle Creek Winter-run Chinook Salmon Reintroduction Plan and the Battle Creek Habitat Restoration Project is also expected to provide a buffer against climate change by creating an additional spawning population (Battle Creek reintroduction) and improving habitat conditions that may increase abundance and survival.

11.1.7 Summary of Risk to Sacramento River winter-run Chinook Salmon

The proposed action will result in ongoing adverse effects to Sacramento River winter-run Chinook salmon. The most significant adverse effects, as described throughout this Opinion, are temperature dependent egg mortality that will occur in all of the Summer Cold Water Pool Management tier types, but most significantly in tier 3 and 4 years. Downstream, 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 facilities where fish can be injured and/or lost to predation and other factors.

In 2009, NMFS reviewed the effects of the proposed operations of the CVP and SWP and issued an Opinion that concluded the effects resulted in an appreciable reduction in both the survival and recovery of Sacramento River winter-run Chinook salmon and developed, in coordination with Reclamation and DWR, a Reasonable and Prudent Alternative (amended in 2011) with 72 actions that avoided jeopardizing the continued existence of the ESU.

The Proposed Action includes many components that were developed through an iterative process after the first biological assessment was issued to NMFS in January, 2019. The iterative process included NMFS sufficiency reviews, draft effects analyses that identified areas where the action was likely to place the individuals and the ESU at high risk, many director meetings where these high risk situations were elevated and Reclamation changed the proposed action to reduce these risks. As previously described, this iterative process resulted in Reclamation identifying specific actions that would improve Shasta Storage, a commitment to stay within Summer Cold Water Management Tiers, the development of Upper Sacramento Performance Metrics and four and eight year independent panel reviews, a financial commitment to reintroduction work on Battle Creek, Delta Cross Channel operational commitments, and the Delta Performance Objectives to cap juvenile loss at the export facilities at the rates experienced over the past 10 years.

The proposed action analyzed in this Opinion does not include all of the actions that NMFS relied on in the RPA to avoid jeopardy. For example, Reclamation did not carry forward the Fish Passage Program, which was expected to reduce the adverse effects related to Shasta operations on listed anadromous fish, the risk of temperature-related mortality of fish and eggs, especially in critically dry years and improve the spatial structure of the ESU. Other RPA actions were not explicitly carried forward into the proposed action, but through the course of the consultation the goals and objectives of those RPA actions were adopted by Reclamation. For example, the proposed action includes the Summer Cold Water Pool Management strategy, discrete actions for improving Shasta storage, a commitment to staying within temperature tiers, and performance measures that were proposed to ensure a sufficient cold water pool to provide suitable temperatures for winter-run spawning in most years, without sacrificing the potential for cold water management in a subsequent years. The proposed action includes a clear funding commitment to support the Battle Creek Winter-run Chinook Salmon Reintroduction Plan which is expected to create a second population of winter-run in Battle Creek. This action will partially compensate for unavoidable project-related effects on the one remaining population and will contribute to an increase in the abundance, productivity and spatial structure of the ESU.

The proposed action also includes components that address 2009/2011 objectives to reduce the likelihood of entraining emigrating juveniles into the southern or central Delta through the Delta Cross Channel or other pathways, and that will reduce mortality of emigrating juveniles lost at export facilities. New Delta Performance Objectives will inform future curtailment actions that will control the net negative flows in Old and Middle rivers and reduce the likelihood that fish will be entrained or lost. The continued use of technical groups will assist in determining real-time operations decisions and evaluating their effectiveness.

Since 2009, Reclamation has taken action on several of the RPA actions including the construction of a new pumping facility and fish screen and discontinuing the use of the Red Bluff Diversion Dam and Fish Ladder, which now allows unimpeded fish passage past the dam site. Recent and ongoing actions to improve adult salmonid and sturgeon passage through the Yolo Bypass, at the Fremont Weir, by modifying or removing barriers. NMFS expects that ongoing Reclamation actions in the Yolo Bypass will improve juvenile growth and survival through floodplain habitat restoration. There has been other measured progress to address risk factors and recovery criteria for winter-run Chinook salmon. For example, the Wallace Weir Fish Rescue Project replaced the seasonal earthen dam at Wallace Weir with a permanent, operable structure that would provide year-round operational control and significantly reduce the number of adult winter-run Chinook salmon that can stray in the CBD. This action should increase the number of salmon that are able to reach spawning habitat and should result in improved abundance of the population. The Battle Creek winter-run “jump start” project initiated early reintroductions of winter-run Chinook salmon into Battle Creek and over 200,000 smolts were successfully released into the North Fork of Battle Creek in both 2018 and 2019 with the program expected to formerly transition into implementation of the Battle Creek Winter-run Chinook Salmon Reintroduction Plan.

The proposed action includes measures to address the effects of climate change and drought including the use of conservative forecasts to make operational decisions and develop Summer Cold Water Pool Management plans, the proposal to develop a Drought and Dry Year Actions toolkit, Tier 4 Intervention Measures and a commitment from SRS Contractors to meet and confer on possible actions during Tier 3 and 4 years. The strategy to proactively address future drought conditions will improve the effectiveness of maintaining Sacramento River winter-run Chinook salmon abundance and productivity in high-risk years.

As described in the Analytical Framework of this Opinion, the risk to the Sacramento River winter-run Chinook salmon ESU posed by the proposed action is evaluated in the aggregate context of the the species' status, the environmental baseline, cumulative effects, and effects from interrelated and independent 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 Central Valley Project 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 Sacramento River winter-run Chinook salmon ESU (National Marine Fisheries Service 2014b). Several elements of the proposed action are aligned with or directly implement recovery actions identified in the recovery plan. Examples include, but are not limited to:

- Establishing 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 winter-run Chinook salmon, spring-run Chinook salmon, and 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.
- Installing fish exclusion devices at strategic locations to reduce migration of listed, adult salmonids into the Colusa Basin Drain complex.
- Reduce hydrodynamic and biological impacts of exporting water through Jones and Banks pumping plants.
- Minimize the frequency, magnitude, and duration of reverse flows in Old and Middle River to reduce the likelihood that fish will be diverted from the San Joaquin or Sacramento rivers into the southern or central Delta.

- Implement projects to minimize predation at weirs, diversions, and related structures in the 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.
- Protect, enhance, and restore a complex portfolio of habitats throughout Suisun, San Pablo, and San Francisco bays to provide cover and prey resources for migrating salmonids.
- Several specific temperature management, restoration, and gravel augmentation actions in key Sacramento and San Joaquin river areas and tributaries, which were also included in the 2009 CVP BiOp RPA (National Marine Fisheries Service 2009b).

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 Sacramento River winter-run Chinook salmon in the future.

After considering its current rangewide status, the environmental baseline within the action area, the effects of the proposed action, effects of any interrelated and interdependent actions, 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 Sacramento River winter-run Chinook salmon ESU.

11.2 Sacramento River Winter-run Chinook Salmon Effects on Critical Habitat

Critical habitat designation for Sacramento River winter-run Chinook salmon includes the Sacramento River from Keswick Dam (river mile 302) to the westward margin of the Delta; all waters westward to the Carquinez Bridge; all waters of San Pablo Bay westward of the Carquinez Bridge; and all waters of San Francisco Bay north of the San Francisco-Oakland Bay Bridge from San Pablo Bay to the Golden Gate Bridge ((58 FR 33212); June 16, 1993). The proposed action area encompasses the entire range wide riverine and estuarine critical habitat for this ESU and affects the functioning of many of its physical and biological features:: (1) access from the Pacific Ocean to appropriate spawning areas in the upper Sacramento River; (2) the availability of clean gravel for spawning substrate; (3) adequate river flows for successful spawning, incubation of eggs, fry development and emergence, and downstream transport of juveniles; (4) water temperatures between 42.5 and 57.5°F for successful spawning, egg incubation, and fry development; (5) habitat 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 San Francisco Bay and the Pacific Ocean.

Currently, many of the essential physical and biological features of 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 physicalphysicalphysical and biological features that support juvenile rearing and outmigration by degrading and limiting access to the floodplain. 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.

Ongoing and proposed activities associated with the proposed action that affect the functioning of essential physical and biological features 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
- Funding habitat restoration and fish passage improvements

The effects of these proposed activities on the physical and biological features of designated critical habitat are characterized as those that provide for successful spawning, rearing, and migration below.

11.2.1 Spawning, Incubation, and Emergence

Water temperatures in the reach between Keswick Dam and the Clear Creek gauging station, where most spawning occurs, have generally been sufficiently cold to support spawning in most years. However, this reach still exceeds lethal temperatures during some critical summer months in years with lower reservoir storage. The proposed action includes cold water pool management aimed at maintaining suitable temperatures for spawning and incubating 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.

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 will also improve spawning habitat quality compared to current conditions by mobilizing gravels for downstream transport. The proposed action also includes projects to add spawning gravels to the system. Reclamation’s funding for the Battle Creek Restoration Project also will maintain or increase the amount of available suitable spawning and incubation habitat.

11.2.2 Rearing

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 not change the quantity (weighted useable area) of rearing habitat except for decreases in floodplain inundation during the September to November outmigration period. Reclamation proposes to at least partially offset this reduction by creating 40 to 60 acres of rearing habitat in the upper Sacramento River.

In the Delta, the proposed flow releases to manage for water quality and smelt habitat are likely to maintain or increase the suitability of available rearing habitat. The proposed expansion of the period of water transfers into October and November is likely to increase flow releases from upstream reservoirs to improve water quality, but may also enhance rearing habitat during these months. Increased flows into the Delta are also likely to enhance the forage base compared to current conditions by altering the movement of nutrients. Reclamation proposes to restore 6,000 acres of tidal habitat to offset effects of flow management. Construction effects will include contaminant introduction and temporary reductions in water quality and the forage base, but these projects will provide a net increase in suitable rearing habitat within one to two years after construction and for many years into the future.

Improvements to habitat in Battle Creek from the implementation of the reintroduction plan and the restoration project are expected to improve rearing habitat through improvements in streamflow and water temperature.

11.2.3 Migratory Corridors

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 outmigration, reducing the quality of these physical and biological features. Temperatures are generally considered adequate for adults during the early migration period and the proposed temperature operations would slightly improve temperature conditions. Reclamation's commitment to fund the repairs the Knights Landing Outfall Gates will prevent adult fish from migrating into the Colusa Basin where they would become isolated and disconnected from the Sacramento River migration corridor. 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 on the North Fork, with the recent removal of Wildcat Dam and ongoing fish passage improvements associated with fish screens and fish ladders at other dams.

In the Delta, additional water exports at the CVP/SWP pumping plants that reverse flows in the Old and Middle Rivers impair routing and timing for outmigrating juveniles. Water releases for 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. 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 outmigration to minimize entrainment of juveniles and delay of adults, maintaining these aspects of the physical and biological features of the migration corridor during this time.

11.2.4 Synthesis of Impacts to Critical Habitat

The entirety of critical habitat designated for winter-run Chinook salmon is within the action area and potentially affected by the proposed action. The essential physical and biological features 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 physical and biological features and slow or limit 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. Spring pulse flow releases are expected to promote channel habitat forming processes, and in combination with habitat restoration actions are expected to largely offset the effects of past and ongoing flow management.

Although the physical and biological features of critical habitat for Sacramento River winter-run Chinook salmon have been highly degraded, the proposed action will offset some past effects of the CVP/SWP and improve others. NMFS expects the proposed ongoing operation of the CVP/SWP will result in diminished function of physical and biological features related to spawning, rearing, and migration within designated critical habitat in the action area. The proposed conservation measures, passage improvements, and restoration actions are expected to improve habitat function within the action area such that, on the whole, the function of physical and biological features 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 Sacramento River winter-run Chinook salmon.

11.3 Central Valley Spring-run Chinook Samon

NMFS listed the CV spring-run Chinook salmon ESU as a threatened species in 1999 and reaffirmed the species' status in 2005 and 2016. The Central Valley technical recovery team estimated that there were once 18 or 19 independent populations along with a number of dependent populations within four distinct diversity groups: the northwestern California diversity group, the basalt and porous lava diversity group, the northern Sierra Nevada diversity group, and the southern Sierra Nevada diversity group (Lindley et al. 2004). The latter is no longer a functioning diversity group, but each supported multiple spring-run Chinook salmon populations historically, spreading risk within and among several Central Valley ecotypes.

Major concerns for this ESU are low numbers, poor spatial structure, and low diversity. At this time, demographically independent populations persist only in the northern Sierra Nevada diversity group (Mill, Deer, and Butte creeks, which are tributaries to the upper Sacramento River) (National Marine Fisheries Service 2014b). The northern Sierra Nevada diversity group contains smaller, dependent populations in Antelope and Big Chico creeks and the Feather and Yuba rivers (California Department of Fish and Game 1998). The northwestern California diversity group contains two small populations, in Clear and Beegum creeks. In the basalt and porous lava diversity group, a small population persists in Battle Creek in addition to a spawning aggregation in the Sacramento River downstream of Keswick Dam.

National Marine Fisheries Service (2016a) concluded that run sizes are declining over time in most of the CV spring-run Chinook salmon populations. Exceptions are the populations in Clear Creek, Battle Creek, and Butte Creek, which have seen recent growth. In particular, the number of spawners in the Battle Creek population, which was extirpated for decades, has increased 18 percent over the last decade and is trending towards a low- to moderate risk of extinction. The population in Clear Creek has been increasing and is comprised mostly of natural-origin fish, although Lindley et al. (2004) classified this population as a dependent population (not expected to exceed the low-risk population size threshold of 2,500 fish). The Butte Creek spring-run Chinook salmon population has increased in part due to extensive habitat restoration and the accessibility of floodplain habitat in the Sutter-Butte Bypass for juvenile rearing in most years (Williams et al. 2016).

Adult CV spring-run Chinook salmon are vulnerable to the effects of climate change because they over-summer in freshwater streams before spawning in the fall (Thompson et al. 2011). This ESU spawns primarily in tributaries to the Sacramento River and those tributaries without cold water refugia (usually input from springs) will be more susceptible. Even in tributaries with cold water springs, unsuitable (warm) instream conditions would be likely after years of extended drought. Juvenile spring-run juvenile Chinook salmon would be susceptible to these conditions because they often rear in their natal stream for one to two summers before emigrating (National Marine Fisheries Service 2016a).

Based on the severity of the recent drought and the low escapements, as well as increased pre-spawn mortality in Butte, Mill, and Deer creeks in 2015, these CV spring-run Chinook salmon strongholds could deteriorate into high extinction risk in the coming years based on the population size or rate of decline criteria (National Marine Fisheries Service 2016a). This predicted trend was validated in recent years through escapement data collected by CDFW for Mill and Deer creeks (California Department of Fish and Wildlife 2019a). With adult returns below 500 individuals for the fourth consecutive year (2015-2018), these populations are at an increased risk of extinction (Lindley et al. 2007). Although adult returns to some spawning tributaries showed a rebound in 2019 (e.g., on Butte Creek, CDFW estimated an adult escapement of 6,253), but not enough final escapement numbers are all available for the ESU to determine if other populations saw a similar response.

The recovery plan (National Marine Fisheries Service 2014b) listed a number of threats to the recovery of the Central Valley spring-run Chinook salmon ESU. Of these, passage barriers at Keswick and Shasta dams that block access to historical habitat in the upper Sacramento River watershed and barriers on Deer and Mill creeks that impede passage to existing habitats are ranked as very high stressors. The loss of rearing habitat in the lower and middle sections of the Sacramento River and the Delta and entrainment and predation in the Delta are also described as highly ranked stressors that are affected by the proposed action. Other threats include, but are not limited to operation of antiquated fish screens, fish ladders, and diversion dams; inadequate flows; and levee construction and maintenance projects that have greatly simplified riverine habitat and disconnected rivers from the floodplain (National Marine Fisheries Service 2016a).

There have been many actions taken over past 20 years to address risk factors faced by CV spring-run Chinook salmon. On Clear Creek, Reclamation removed McCormick-Saeltzer Dam in

2000 which restored passage to approximately 12 miles of holding and spawning habitat. Other improvements on Clear Creek have included spawning gravel augmentation, floodplain restoration and side channel restoration projects. On the upper Sacramento River, Reclamation and others have been restoring side-channel rearing habitat and augmenting spawning habitat with spawning gravels. On Battle Creek, the Battle Creek Salmon and Steelhead Restoration Project has been improving fish passage and similar actions have been undertaken on Mill Creek and Butte Creek. On Butte Creek, a combination of fish passage improvements and flow and temperature management actions have resulted in significant increases in the population. Reclamation, through the CVPIA, has funded fish screening projects on the largest water diversions in the Sacramento Valley.

The most significant effects of the proposed action on individuals from this ESU are expected to be those of water temperature management in the upper mainstem Sacramento River, spring pulse flows, operation of the Delta Cross Channel gates, and CVP/SWP south Delta export operations. The likely effects on individuals and the viability of populations in the affected diversity groups are reviewed in the following sections.

11.3.1 Water Temperature Management in the Upper Sacramento River

Reclamation's management of the cold water pool in Shasta Reservoir, developed to protect the redds of winter-run Chinook salmon, is expected to result in mortality of some eggs and fry of spring-run Chinook salmon between Keswick Dam and the Clear Creek gauge. Temperatures will exceed the lethal temperature of 53.5°F in 76 percent of days during August through October under Tier 1, 80 percent of days under Tier 2, 97 percent of days under Tier 3, and 100 percent of days under Tier 4. NMFS assumes that this is a conservative metric (i.e., overestimates likelihood of egg and fry mortality) because these temperature exceedances would be observed at the Clear Creek gauge at furthest downstream point of winter-run Chinook salmon spawning where the mainstem temperatures are influenced by inflow from warmer tributaries (i.e., many fish will likely spawn further upstream where temperatures would be better). Reclamation therefore proposes to provide flows that result in 53.5°F at the Clear Creek gauge when the working group determines, based on real-time monitoring, that 95 percent of winter-run Chinook salmon eggs have hatched and their alevins have emerged, or on October 31st, whichever is earlier. Although designed to protect redds in the downstream portion of the spawning area, NMFS expects that this action also will reduce the risk of temperature dependent mortality for spring-run Chinook eggs in the upper mainstem spawning area. Considering that the spawning area used by spring-run Chinook salmon overlaps both temporally and spatially with that of fall-run Chinook salmon, it is difficult to estimate the magnitude of the benefit that water temperature management will have on the numbers and productivity of this dependent spring-run population, but NMFS expects it will provide some support for the numbers, productivity, and spatial distribution of the northern Sierra Nevada diversity group.

11.3.2 Spring pulse flows in the mainstem Sacramento River

Reclamation's proposal to store cold water in Lake Shasta to protect winter-run Chinook redds will reduce flows in the mainstem Sacramento River during spring when juvenile spring-run Chinook are present. Reclamation therefore proposes to release pulsed flows that improve migration habitat for this ESU when the projected total storage in Shasta Reservoir on May 1st indicates that sufficient cold water will be present for both the pulses and summer cold water pool management without interfering with the ability to meet performance objectives or other anticipated operations of the reservoir. NMFS estimates that Reclamation could have released a 150 thousand acre-feet pulse flow in 57 percent of years and a smaller pulse flow in 8 percent of years based on an analysis of historical hydrologic conditions. Ongoing effects of climate change in the upper Sacramento basin are likely to reduce these frequencies in the future, but the extent of this reduction and the rate of change are highly uncertain.

NMFS expects that, to the degree sufficient storage is available, Reclamation's commitment to release spring pulse flows will address an important threat, described in the recovery plan, for three of the four diversity groups of Central Valley spring-run Chinook salmon by increasing the quality of juvenile migration habitat in the mainstem Sacramento River. This is expected to improve the abundance and productivity of the remaining independent populations as well as the dependent populations in the northwestern California, northern Sierra Nevada, and basalt and porous lava diversity groups.

11.3.3 Operation of the Delta Cross Channel gates

As described for Sacramento River 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 1st (and during December and January when there are water quality issues) would be likely to encounter open gates. Reclamation will therefore continue to use real time monitoring to decide when enough fish are present to close the gates. This is expected to limit entrainment into the Delta Cross Channel and the interior Delta, northwestern California, northern Sierra Nevada, and basalt and porous lava diversity groups.

11.3.4 South Delta Export Operations

Reclamation proposes to extend the number of days that water transfers can occur for both project and non-project water supplies through the Central Valley Project and the State Water Project. This operation is likely to affect juvenile CV spring-run Chinook salmon by increasing the risk of entrainment into the export facilities. Negative effects include direct (local) mortality, which includes pre-screen loss and imperfect fish guidance efficiency at louvers or screens and far-field mortality associated with south Delta pumping and fish salvage operations. Assuming that the relationship between spring-run escapement and number of juveniles entering the Delta is similar to that for winter-run Chinook salmon, NMFS expects losses between less than one to five percent of juvenile spring-run Chinook salmon entering the Delta in those years. Reclamation proposes to limit the risk for this ESU by using Delta Performance Objectives designed for Sacramento River winter-run Chinook salmon and CCV steelhead. This is a reasonable approach because several factors (especially the co-mingling of young-of-year Chinook salmon salvaged from late March onward with unmarked hatchery fall-run Chinook salmon and the poor ability of the length-at-date criterion to distinguish between the two species) present logistical challenges in defining separate numerical thresholds. NMFS therefore accepts that it is appropriate to use the Sacramento River winter-run Chinook salmon threshold as a proxy to protect early emigrating yearling CV spring-run Chinook salmon. It is also reasonable to use the Delta Performance Objective for CCV steelhead as a proxy for CV spring-run Chinook salmon due to their similar emigration timing. NMFS assumes that the thresholds in place for CV steelhead during April and May are likely to maintain the loss levels for CV spring-run Chinook salmon at levels that are comparable to the last ten years.

Reclamation and DWR further propose to minimize the likelihood of effects related to water exports by using the salvage of yearling Coleman hatchery late-fall Chinook salmon as a surrogate for yearling spring-run Chinook salmon. If the rate of salvage exceeds 0.5 percent of any Coleman hatchery late-fall release group, storm-related operational flexibility will not be taken and reverse flows in the Old and Middle Rivers will be managed at -5,000 cfs or lower. NMFS expects that these Old and Middle Rivers Storm-related Flexibility triggers, combined with the Delta Performance Objectives, will provide reasonable levels of protection for CV spring-run Chinook salmon.

11.3.5 Conservation Measures

Reclamation proposes several conservation measures to improve the survival of the affected life stages of CV spring-run Chinook salmon. The most significant actions include:

- Battle Creek Salmon and Steelhead Restoration Project
- Clear Creek Pulse Flows
- Deer Creek Fish Passage Improvements
- Small fish screen program
- Knights Landing Outfall Gates
- Spring Pulse Flows
- Tidal Habitat Restoration
- Predator Hot-spot Removal
- SRS Contractors Salmon Recovery Program

The proposed conservation measures are expected to help CV spring-run Chinook salmon withstand adverse effects of the proposed action with an expectation that they will contribute to an increase in the abundance and productivity of populations throughout the Central Valley. The pace of Sacramento River habitat restoration has been high in recent years with multiple projects being completed annually due to a strong partnership among the Northern California Water Association, the Western Shasta Resource Conservation District, the Sacramento River Forum, Chico State University, local landowners, and the five agency family of CDFW, DWR, NMFS, FWS, and Reclamation.

11.3.6 Climate Change Considerations

As previously described in this Opinion, adult CV spring-run Chinook salmon key on snow melt runoff to access their higher elevation holding and spawning habitat. Thus, the shift from later runoff from snowmelt to earlier runoff form 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 Battle Creek Salmon and Steelhead Restoration Project and the Deer Creek Fish Passage action will also continue to improve upstream passage conditions for spring-run Chinook salmon. Together, these actions are expected to partially offset the expected effects climate change.

11.3.7 Summary of Risk to Central Valley Spring-run Chinook Salmon

In 2009, NMFS reviewed the effects of the proposed operations of the CVP and SWP and issued an Opinion that concluded the effects resulted in an appreciable reduction in both the survival and recovery of CV spring-run Chinook salmon and developed, in coordination with Reclamation and DWR, a Reasonable and Prudent Alternative (amended in 2011) with 72 actions that avoided jeopardizing the continued existence of the ESU.

The proposed action analyzed in this Opinion does not include some of the actions that NMFS relied on in the RPA to avoid jeopardy. Most notably, Reclamation did not carry forward the Fish Passage Program, which was expected to reduce the adverse effects related to Shasta operations on listed anadromous fish, the risk of temperature-related mortality of fish and eggs, especially in critically dry years and improve the spatial structure of the ESU. Other RPA actions that were intended to avoid jeopardizing CV spring-run Chinook salmon were not explicitly carried forward into the proposed action, but the goals and objectives of those RPA actions were adopted by Reclamation over the course of this consultation since Reclamation first issued its biological assessment to NMFS in January, 2019. The iterative process included NMFS's sufficiency reviews, draft effects analyses that identified areas where the action was likely to place individuals and the listed species at high risk, and director meetings where these high risk situations were elevated. As previously described, this iterative process resulted in Reclamation identifying specific additional action items including a $14 million commitment to the Battle Creek Salmon and Steelhead Restoration Project, improving fish passage on Deer Creek, and reducing the risk or straying into the Colusa Basin through improvements to the Knights Landing Outfall Gates. Although, there are no specific Delta Performance Metrics for CV spring-run Chinook salmon, Reclamation described how the metrics for the measures for winter-run Chinook salmon and steelhead overlap would provide a surrogate form of protection for this ESU, capping juvenile losses to the rates experienced over the last ten years despite an extended time period for exports. The spring-run triggers for storm-related Old and Middle Rivers flexibility should reduce exposure and effects related to this action to minor levels.

Despite these additional actions, the proposed action will result in some adverse effects to CV spring-run Chinook salmon. Similar to Sacramento River winter-run Chinook salmon, most significant are temperature dependent egg and fry mortality in the upper mainstem Sacramento under all Summer Cold Water Pool Management tier types, but most significantly in Tier 3 and 4 years. We also expect adverse effects related to water temperatures that could affect spawning success in Clear Creek. Downstream, the action will result in adverse near and far-field effects from project-related changes in Delta hydrodynamics. At the Delta Export facilities, operations of the pumps will result in some entrainment into the facilities where fish can be injured and/or lost to predation and other factors.

In addition, Reclamation is already implementing several of the 2009 RPA actions those expected to improve adult salmonid and sturgeon passage through the Yolo Bypass and at the Fremont Weir by modifying or removing barriers. NMFS expects that Reclamation's actions in the Yolo Bypass will improve juvenile growth and survival through floodplain habitat restoration. Other progress to address risk factors and meet recovery criteria for CV spring-run

Chinook salmon Chinook salmon include the Wallace Weir Fish Rescue Project that replaced the seasonal earthen dam at Wallace Weir with a structure that provides year-round operational control and significantly reduces the number of adult Chinook salmon that can stray in the Calusa Basin Drain.

As described in the Analytical Framework 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 Central Valley Project 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 or possibly improve the abundance, productivity, spatial structure, and diversity of the ESU.

NMFS has finalized recovery planning for the CV spring-run Chinook salmon ESU (National Marine Fisheries Service 2014b). Several elements of the proposed action are aligned with or directly implement recovery actions identified in the recovery plan, as described in Section 11.1.7.

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.

Considering its current rangewide status, the environmental baseline within the action area, the effects of the proposed action and of any interrelated and interdependent actions, 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.

11.4 Central Valley Spring-run Chinook Salmon Effects on Critical Habitat

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 ((70 FR 52488); September 2, 2005). The Physical and biological features for CV spring-run Chinook salmon critical habitat include (1) freshwater spawning sites, (2) freshwater migratory corridors, (3) freshwater rearing sites, and (4) estuarine habitat. The entirety of the proposed action area north of where the Sacramento River meets Sherman Lake in the Delta is within the designated critical habitat for CV spring-run Chinook salmon. Individuals from all CV spring-run diversity groups must pass through the Delta in their migrations to and from the Pacific Ocean.

Passage impediments have contributed to substantial reductions in suitable habitat available to CV spring-run Chinook salmon by isolating them from much of their historical spawning habitat. The function of physical and biological features of critical habitat below barriers within the currently designated critical habitat are highly degraded. Spawning habitat is constrained by the availability of suitable temperatures in downstream areas, and water temperatures in the late summer and fall are often negatively affected by operation of the CVP through warm water releases from Shasta Reservoir, although these operations also result in cooler downstream temperatures during summer months than would have existed under pre-dam conditions. The existence of dams also limits recruitment of gravel for spawning substrate, and ongoing operation of the dams limits habitat-forming processes. Freshwater rearing and migration physical and biological features within the Sacramento River have been degraded 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. Continuing effects of habitat destruction from gravel mining and historical gold mining activities as well as ongoing activities in the San Francisco Bay and Delta (including dredging, water exports, vessel traffic, and food web disruption from invasive species) continue to further limit habitat quality across the designated area.

As described above in the *Effects to Species* section, there have been many efforts to repair or restore the degraded condition of the physical and biological features of critical habitat for CV spring-run Chinook salmon over the last ten years. These actions have improved the freshwater spawning sites through water temperature management and spawning gravel augmentation; the migratory corridor through dam removal and fish passage improvements using fish ladders and through selective barrier installations such as at the Wallace Weir; freshwater rearing sites through habitat restoration projects and fish screen installation on water diversions; and estuarine habitat through habitat restoration and improvements to Delta operations.

Ongoing and proposed activities associated with the proposed action that affect the functioning of essential physical and biological features 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
- Spring pulse flows
- Deer Creek Fish Passage Improvements
- Knights Landing Outfall Gate Repairs
- Spawning and rearing habitat improvements through the Collaborative Planning action component
- Small screen program
- Dry year management planning
- Funding habitat restoration and fish passage improvements.

The effects of these proposed activities on the physical and biological features of designated critical habitat are characterized as those that provide for successful spawning, rearing, and migration below.

11.4.1 Spawning, Incubation, and Emergence

Temperatures in the mainstem Sacramento River will continue to be elevated in the months of August through October under the proposed action, the peak spawning period for CV spring-run Chinook salmon. Spawning habitat quantity and quality in Clear Creak has been reduced by unsuitable water temperatures under past CVP operations. Reclamation has therefore proposed to manage releases from Whiskeytown Dam to maintain suitable temperatures for spawning and incubation (56 deg F) through October of most years.

Proposed minimum instream flows under the proposed action will support spawning, incubation of eggs, fry development and emergence for CV spring-run Chinook salmon. Reclamation's analyses show proposed reduced fall flows are likely to increase the weighted useable area of spawning habitat for CV spring-run Chinook in some fall months in the reaches immediately below Keswick Dam. Proposed flows will not affect the amount of gravel entering the mainstem from the tributaries, but will continue to limit its downstream transport. Reclamation's proposed channel maintenance and spring pulse flows, are expected to at least partially offset these effects by mobilizing gravels and increasing the function and extent of spawning and incubation habitat. In Clear Creek, proposed pulse and maintenance 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 physical and biological features in this reach. In addition to operational measures, the proposed action also includes a number of projects to improve spawning habitat for Chinook salmon. These include adding spawning gravels to the Sacramento River system and funding the Battle Creek Restoration Project.

11.4.2 Rearing

Reclamation's proposed flow operations will continue to maintain a similar extent of rearing habitat within the action area compared to current conditions. Shasta Dam water operations will continue to limit the extent of cold water rearing habitat in the mainstem Sacramento River once the cold water pool has been used, degrading juvenile rearing habitat during fall in drier years. Reclamation's analysis of weighted usable area for juvenile rearing showed that this will be reduced in the reaches just below Keswick Dam during January and February. Water temperatures in the lower Sacramento River are expected to continue to be warm (i.e., suboptimal for rearing and growth) in the summer months. During the proposed fall and winter flows, access to riparian juvenile rearing habitat in the upper middle Sacramento River may improve, and floodplain inundation is expected to be the same or greater from December through August. In Clear Creek, the proposed action generally maintains current water temperatures and flows for rearing in all but the lowest section. While CVP operations would continue to limit channel- and habitat-forming processes in the action area, proposed pulse flows, channel flows, and habitat restoration actions (i.e., the Battle Creek restoration project) are expected to largely offset these effects. The proposed action is unlikely to affect contaminant levels or sources in the action area.

11.4.3 Freshwater Migration Corridors

Proposed flows in the upper Sacramento River are generally sufficient to maintain connectivity between spawning/rearing and migration habitat. Temperatures may exceed thresholds for adult migration during the summer months, but would be slightly lower under the proposed action than current conditions. Proposed flows are expected to be lower in the fall than under current operations, reducing the quality of juvenile and adult migration corridors during those months. The proposed spring pulse flows on the Sacramento, however, will improve migration conditions in years when the operation can be implemented. In Clear Creek, proposed temperature management will increase flows during the fall, improving migration conditions for juveniles and adults. Ongoing and future actions on Battle Creek will remove obstructions and reduce delays in the migration corridor. These include the recent removal of Wildcat Dam on the North Fork and ongoing fish passage improvements associated with fish screens and fish ladders at other dams. Fish passage improvements on Deer Creek will improve the adult migration to upstream holding and spawning habitat. Reclamation’s commitment to fund repairs of the Knights Landing Outfall Gates will also improve the function of physical and biological features of freshwater migration corridors for adults in the action area.

11.4.4 Estuarine Habitat

In the Delta, proposed flow releases to manage for water quality and smelt habitat are likely to maintain or increase the quality of available rearing habitat in the northern Delta and estuarine reaches of the mainstem lower Sacramento River. Proposed changes to expand the period of water transfers to October and November will enhance rearing habitat in the Delta by increasing flows to improve water quality. Increased flows are also likely to slightly enhance the forage base compared to current conditions. Modifications of flows to alter nutrient movement into the Delta will cause a minor benefit in forage base, but cause minor decreases in water quality. However, most of this change is likely to occur beyond the downstream extent of designated critical habitat for CV spring-run Chinook salmon. The restoration of 6,000 acres of tidal habitat may temporarily degrade rearing habitat during construction, followed by long-term habitat improvement, but it is unknown how many of these acres would be within designated habitat for CV spring-run Chinook salmon given its limited extent within the Delta.

In the northern Delta, increases in flows due to the proposed action would be expected to improve the quality of migration habitat for juveniles in October and November compared to current conditions by increasing flow velocity in the main channels. Water releases for management of Delta smelt habitat are also expected to provide minor improvements to flows in the migration corridor. Proposed operation of the Delta Cross Channel is expected to reduce habitat function in the migration corridor by delaying juveniles and adults or re-directing them through routes with poorer passage or survival conditions. Proposed periodic closures of Delta Cross Channel gates are expected to reduce the entrainment of juveniles and delay the migration of some adults. However, because these closures have little overlap with the peak period of adult migration, the functioning of this portion of the migration corridor will still be reduced for this ESU.

11.4.5 Synthesis of Impacts to Critical Habitat

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 physical and biological features and slow or limit 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.

Proposed CVP operations are expected to continue to limit the function of the physical and biological features of freshwater critical habitat by increasing water temperatures in fall months and altering flow, gravel transport, and other habitat forming processes in the Sacramento River basin. However, the proposed action includes measures such as channel and pulse flows and gravel augmentation to offset these continuing effects. Proposed operations to benefit water quality in the Delta will improve juvenile rearing habitat in the estuarine portions of the lower Sacramento River and northern Delta, but water temperature management operations will reduce the quality of physical and biological features in freshwater migration corridor compared to current conditions, particularly for adult CV spring-run Chinook salmon that are expected to encounter warmer temperatures during peak migration. Reclamation will fund fish passage improvements in Battle Creek, Deer Creek, and at Knights Landing to improve conditions in the migration corridor and provide access to additional spawning and rearing habitat.

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 physical and biological features of critical habitat for CV spring-run Chinook salmon have been highly degraded, the proposed action will offset some past effects of the CVP and improve others. the proposed action will offset some past effects of the CVP/SWP and improve others. NMFS expects the proposed ongoing operation of the CVP/SWP will result in diminished function of physical and biological features related to spawning, rearing, and migration within designated critical habitat in the action area. The proposed conservation measures, passage improvements, and restoration actions are expected to improve habitat function within the action area such that, on the whole, the function of physical and biological features 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 Central Valley spring-run Chinook salmon.

11.5 California Central Valley Steelhead Effects on the Species

NMFS listed the CCV steelhead DPS as a threatened species in 1998 and reaffirmed the species' status in 2005 and 2016. Before dam construction, water development, and other watershed perturbations, CCV steelhead were found from the upper Sacramento and Pit rivers (now inaccessible due to Shasta and Keswick dams) south to the Kings and possibly the Kern River systems, and in both east- and west-side Sacramento River tributaries (National Marine Fisheries Service 2014b). There may have been at least 81 independent populations, distributed primarily throughout the eastern tributaries of the Sacramento and San Joaquin rivers. Currently, steelhead spawn in the Sacramento, Feather, Yuba, American, Mokolumne, Stanislaus, and Tuolumne rivers and tributaries, including Cottonwood, Antelope, Deer, Clear,Mill, and Battle creeks. Spawning likely occurs in other streams, but the lack of a comprehensive Central Valley steelhead monitoring program makes the amount and extent of spawning difficult to know. The four bio-geographic regions currently occupied by this species are the northwestern California diversity group, the basalt and porous lava diversity group, the northern Sierra Nevada diversity group, and the southern Sierra Nevada diversity group. Major concerns across the range include passage impediments and barriers, warm water temperatures for rearing, hatchery effects, limited quantity and quality of rearing habitat, predation, and entrainment.

Many watersheds in the Central Valley are experiencing decreased abundance of CCV steelhead (National Marine Fisheries Service 2016b). Dam removal and habitat restoration efforts in Clear Creek appear to be benefiting the DPS as observers have reported unclipped (naturally-produced) steelhead in recent years. However, adult numbers are still low, a large percentage of the historical spawning and rearing habitat is lost or degraded, and smolt production is dominated by hatchery fish. Many planned restoration and reintroduction efforts have yet to be implemented or completed. Most natural origin CCV steelhead populations are not monitored and may lack the resiliency to persist for protracted periods if subjected to additional stressors, particularly widespread stressors such as climate change and drought (National Marine Fisheries Service 2016b).

The recovery plan (National Marine Fisheries Service 2014b) listed a number of threats to the recovery of the CCV steelhead DPS. Of these, passage barriers, water temperature, flow, and entrainment are affected by the proposed action. Other threats include, but are not limited to agricultural diversions, rearing habitat loss, loss of floodplains, hatchery effects, predation and ocean harvest (National Marine Fisheries Service 2014b). Juvenile CCV steelhead are vulnerable to the effects of climate change as freshwater rearing habitat becomes warmer and flows lower, although the proposed flow management actions should counteract these changes to some degree. Adult migrants are less vulnerable to warming temperatures due to their spawn timing, although early-arriving spawners may also encounter unsuitably warm river temperatures.

There have been many actions taken over past 20 years to address risk factors faced by CCV steelhead. On Clear Creek, Reclamation removed McCormick-Saeltzer Dam in 2000 which restored passage to approximately 12 miles of spawning and rearing habitat, and spawning gravel augmentation, floodplain restoration and side channel restoration projects also have improved spawning and rearing habitat for CCV steelhead in Clear Creek. Habitat restoration actions that include spawning gravel augmentation, side channel improvements and in channel rearing habitat features likely have improved conditions for steelhead spawning and rearing on the Sacramento and American rivers. Recent progress has been made to improve floodplain rearing habitat in small, but important areas along the lower Sacramento River at Bullock Bend.

Detailed descriptions regarding the exposure, response, and risk of CCV steelhead to these stressors by division are presented in the *Effects Analysis* of this Opinion. Major impacts of the proposed action to CCV steelhead include warm water temperatures in summer rearing habitats on the American and Stanislaus rivers, low fall and winter flows on the Sacramento River, increased exposure into degraded south Delta habitats, and entrainment and loss at the south Delta export facilities.

11.5.1 Fall and Winter Flows on the Sacramento River

Proposed fall and winter refill operations at Shasta Reservoir are likely to result in average monthly winter flows that are similar to or slightly increased compared to current operations. The most significant change in winter flows are expected in December based on Reclamation’s modeling. This increase is attributable to Reclamation going into flood control more frequently due to fall actions they are taking to build storage. While Reclamation proposes to hold minimum flows lower than they are currently during fall and winter months, the action also increases the frequency and duration that Reclamation will release water from Shasta Reservoir for flood control, and these releases will increase downstream flows compared to current operations. Increased flows during flood control release would improve juvenile rearing and outmigration conditions during the release, but then increase the risk of stranding and redd dewatering when the flows recede. Ramping rate restrictions would reduce the rate at which flows can decrease, reducing this risk. Flood releases would also create the potential for adults to enter temporarily inundated habitat to spawn, and any redds spawned during a flood release would be at risk of dewatering after flows recede back to minimum levels. 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 Upper Sacramento River, are not expected to substantially reduce the productivity, diversity and abundance of the individuals and viability of the population compared to current conditions.

Clear Creek Temperature and Flow Management

Temperature management operations in Clear Creek will continue to benefit rearing juvenile and migrating adult CCV steelhead, although temperaturescan exceed optimal levels rearing on lower reaches of Clear Creek during late summer months. Clear Creek minimum instream flows are designed to address multiple species needs across different seasons but may limit rearing habitat in some reaches and could adversely affect migration cues.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 outmigrate. Such pulses would also expose juveniles to 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 ramping rates should minimize the risk of stranding juveniles. Pulse flows are also expected to improve habitat-forming processes over current conditions. The combined effects of ongoing operations and 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.

11.5.2 American River Flow Fluctuations and Warm Water Temperatures

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 steelhead triggering an increased susceptibility to disease and predation, although this effect is would be most significant from Watt Avenue dowstream. New proposed temperature management operations are expected to slightly reduce thermal stress juveniles are exposed to during the summer and fall compared to current operations, although exposures to daily mean water temperatures are likely to 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.

East Side Division

CCV steelhead in the Stanislaus River will continue to be negatively affected by certain elements of the proposed action. Specifically, steelhead in the Stanislaus 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.

Survival and growth of CCV steelhead in the Stanislaus are affected by release levels below Goodwin Dam that 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 such sources as potential redd dewatering.

Reclamation proposes to operate New Melones Reservoir to provide minimum releases at Goodwin Dam under the proposed stepped release plan. When compared to current operations, the proposed action will provide identical minimum flows in critical, dry, and below normal water years. For above normal water years, Reclamation proposes to provide the same release as below normal water years. In wet years, Reclamation proposes to provide minimum releases equivalent to the current operation's above normal schedule, and the current operation's wet year minimum releases are eliminated. Reclamation also proposes to incorporate input from the Stanislaus Watershed Team (successor to the Stanislaus Operations Group) in the shaping of seasonal flows. Review of modeled water temperatures shows little difference in temperatures between current operations and the proposed action at Goodwin Dam, as water temperatures are largely driven by the temperature of water released from New Melones Reservoir and any warming in Tulloch and Goodwin reservoirs. The effects of altered flows and increased temperatures are expected to be similar for rearing and outmigrating juvenile CCV steelhead in the San Joaquin River below the confluence with the Stanislaus River, although temperatures will be higher in the San Joaquin.

The proposed action also includes restoration of 50 acres of rearing habitat and place 4,500 tons of gravels annually in the Stanislaus River, increasing the availability of suitable spawning and rearing habitat.

The combined effects of the current operations and implementation of the proposed action on the adult immigration, spawning, egg incubation, juvenile rearing, and smolt emigration life stages of CCV steelhead in the Stanislaus River will continue to adversely impact the productivity and survival of individual CCV steelhead. However, the proposed action in the Stanislaus will not reduce the current viability of the population compared.

11.5.3 Delta Cross Channel and Altered Delta Hydrodynamics

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 DCC gates will be closed, except to prevent exceeding a D-1641 water quality threshold. FWSrotary screw trapwater operations management teamFrom February 1 to May 20, the DCC gates will be closed consistent with D-1641. From May 21 to June 15, Reclamation will close the DCC gates for a total of 14 days during this period consistent with D-1641. Reclamation and DWR's risk assessment will consider the Knights Landing rotary screw trap, Delta juvenile fish monitoring program (Sacramento trawl, beach seines), Rio Vista flow standards, 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 timing and duration of the gate closure. We expect these measures to provide protections that are similar to the protections provided by the NMFS 2009 Opinion and RPA.

For CCV steelhead smolts emigrating from December through April, there would be little difference between the proposed action and current operating scenario regarding routing and travel times, and therefore through-Delta survival should not vary much between the two scenarios. This is the period in which 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 steelhead from the Sacramento Basin have already emigrated.

Cross Channel gate operations are also likely to continue to delay migration of some CCV steelhead adults, the majority of which are expected to enter the Delta when the gates are open (August through November). A proportion of these adults will be more likely stray into the San Joaquin River and Mokelumne River system as a result. 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.

11.5.4 Entrainment and Loss at the Delta Export Facilities

Delta export actions at both State and Federal Facilities can create near- and far-field effects on emigrating fish in the Delta including decreased transit times, increase risk of predation and direct salvage and loss (entrainment) at the facilities. Clearly predation is a baseline stressor that is affecting fish in the Delta, but the CVP and SWP include facilities that can influence predation risk through their existence and through operation and maintenance. Reclamation proposes to increase south Delta water exports relative to a current operations scenario and results from the Salvage Density Model indicate that losses of CCV steelhead would increase under the proposed action in the winter and spring months (U.S. Bureau of Reclamation 2019c). The effects of these changes on the relative flow conditions in the Delta are more pronounced in drier year types. Loss increases are expected to be greatest during April and May, coinciding with the peak of juvenile outmigration of CCV steelhead from the San Joaquin Basin. Loss estimates from the salvage-density model correspond to estimates of combined annual loss increase range of one to seven percent of the CCV steelhead juvenile abundance in the Delta under current conditions, and one to eight percent loss to entrainment under the proposed action, although differences varied widely among months and year types. The loss estimates do not include loss due to louver cleaning, predation observed to occur on the upstream side of the trash racks, or far-field predation associated with altered hydrodynamics, and therefore underestimate mortality associated with south Delta pumping and fish salvage operations.

Based on the estimate of increased losses from the Salvage Density Model, Reclamation revised its proposed action with additional Real-time Old and Middle Rivers Restrictions and Performance Objectives including a Cumulative Loss Threshold and a Single-year Loss Threshold. The CCV steelhead Objective is separated into two time periods (December through March and April through June) to provide distinct protections for both Sacramento Basin and San Joaquin-origin fish that historically appear in the Mossdale trawls later than Sacramento origin fish. Both the cumulative loss and the single year thresholds are based on observed losses during 2010-2018. If at any time before 2024, loss at the export facilities exceeds 50 percent of the cumulative loss threshold, Reclamation and the state Department of Water Resources will convene an independent panel to review the actions contributing to the loss trajectory and recommend modifications or additional actions to stay within the cumulative loss threshold. Regardless of the trajectory, Reclamation and DWR will convene the independent panel in the year 2024 to review observations over the past five years of the action and determine whether continuing actions will reliably maintain or improve the trajectory for the duration of the consultation period.

In addition, Reclamation and DWR propose to take actions to avoid exceeding an annual loss threshold equal to 90 percent of the greatest loss that occurred during 2010-2018. If 50 percent of a single-year threshold is exceeded, they will reduce the magnitude of reverse flows through the Old and Middle Rivers to a 14-day moving average of -3,500 cfs unless real-time fish monitoring data shows that the risk is no longer present. If 75 percent of the threshold is exceeded, reverse flows will be reduced to -2,500 cfs, for the remainder of the export season unless the real-time fish monitoring data shows that the risk is no longer present. Similar to the cumulative loss objectives, if the single-year loss threshold is exceeded, an independent panel will be convened to evaluate the efficacy of the actions taken to reduce effects to listed fish species and will provide recommendations for actions to reduce effects in following years.

While loss is expected to occur under the final proposed action, performance objective thresholds are expected to limit loss to levels similar what has been observed over the past 10 years. Estimated loss using the Salvage Density Model results showed the greatest differences between the proposed action and the current operating scenario for the months of April and May, and we expect that the protections related to the revised loss thresholds will be greatest during this April-May period during outmigration of CCV steelhead (particularly from the San Joaquin basin). NMFS expects that reducing the magnitude of reverse flows in the Old and Middle Rivers, when triggered by exceedances of the cumulative and annual loss thresholds, will maintain survival rates of juvenile CCV steelhead as they move through the Delta. In addition, turbidity management, and managing for Delta Smelt entrainment are actions expected to provide additional protections for CCV steelhead migrating through the Delta.

Additional Proposed Action Components in the Delta

In addition to the effects of the actions described above, Reclamation proposed to continue operating several key features of this project within the Delta, including the North Bay Aqueduct, Rock Slough Intake, Suisun Marsh Salinity Control Gates, and South Delta

Agricultural Barriers. These actions are generally expected to continue ongoing effects of project operations, including degrading water quality, increasing risk of entrainment or predation, and slowing or impeding migration in ways that are largely consistent with current operations. However, these effects are expected to be minor, primarily because they have minimal spatial or temporal overlap with CCV steelhead distribution in the Delta. In the case of temporary agricultural barriers, CCV steelhead adults are expected to encounter them during a portion of their migration (September to mid-November), although barriers would be removed during the remainder of the adult migration and notching of the barriers by mid-September is expected to provide some opportunity for passage. 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, and after May 1st these juveniles are expected to experience reduced survival and poorer migration conditions consistent with current operations. While these ongoing effects will contribute to the impacts limiting survival and productivity in the Delta, they are not among the major drivers of productivity, growth, or survival of CCV steelhead in this part of the action area.

Reclamation is also proposing to alter the timing of operations of its intake facilities in the Delta by extending the water transfer window through November. This will result in increased releases from CWP facilities during October and November compared to current conditions. During the period from August through November when adult CCV steelhead are moving upstream into the Sacramento River basin, typical river flows are low. The proposed action does not significantly change flows during this period except during December of certain water year types when flows may increase due to actions that build fall storage and increase the frequency that Shast goes in to flood control. These increased flows will provide stronger migratory cues and stronger olfactory signals to fish moving upriver, and juveniles would encounter improved growth and survival conditions as they migrate downstream toward the Delta.

Conservation Actions

There are several beneficial components of the proposed action including habitat restoration on the Sacramento, American, and Stanislaus Rivers; the small fish screen program; commitments to the Battle Creek Salmon and Steelhead Restoration Project; the Deer Creek Fish Passage action; the Knights Landing Outfall Gate action; the Spring Pulse Flow Action on the Sacramento River; predator removal at fish salvage facilities; and tidal habitat restoration.

Additionally, the SRS Contractors Recovery Program will compliment habitat restoration actions proposed by Reclamation and, although it is not possible to quantify the benefits, they are expected to support spawning and rearing productivity associated with increasing the quantity and quality of spawning substrate and rearing habitat in the upper Sacramento River. The magnitude impact of these actions is medium to high based on past performance of the Reclamation habitat restoration and the SRS Contractors Recovery Plan since 2000. The SRS commitment to the scope, mission and objectives of the Sacramento River Science Partnership is expected to improve the science that is used to protect and support the recovery of CCV steelhead.

Reclamation is also proposing to implement a CCV steelhead Lifecycle Monitoring Program that will develop infrastructure to support a functioning life cycle monitoring program in the Stanislaus River and a Sacramento basin CVP tributary (e.g. Clear Creek, Upper Sacramento, American River) to evaluate 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 these two populations. The goal of this monitoring program will be to improve understanding of steelhead demographics and, when combined with other steelhead-focused parts of the Proposed Action (San Joaquin and Delta steelhead telemetry study), inform actions that will increase steelhead abundance and improve steelhead survival through the Delta.

Another key conservation measure is Reclamation's commitment to complete the HGMP for the Nimbus Fish Hatchery. The Nimbus HGMP was not completed by 2014 as required in the RPA, however, Reclamation is proposing to complete the HGMP as part of the proposed action and within six months of completion of the consultation, Reclamation will work with CDFW and NMFS to establish a clear understanding on this conservation measure's goals, appropriate time horizons, and reasonable cost estimates for this effort. The HGMP will describe hatchery operations and associated monitoring to reduce genetic introgression from the out-of-basin Nimbus Hatchery broodstock, implement practices to reduce straying and eliminate inter-basin transfers from Nimbus hatchery which should improve the fitness of Nimbus Fall-run Chinook salmon.

The proposed conservation measures are expected to help CCV steelhead withstand adverse effects of the proposed action and improve the science that can be used to protect CCV steelhead from adverse effects associated with CVP and SWP water operations. NMFS expects that these measures maintain the abundance, survival and productivity metrics of populations throughout the action area.

Summary of Risk to the DPS

In 2009, NMFS reviewed the effects of the proposed operations of the CVP and SWP and issued an Opinion that concluded the effects resulted in an appreciable reduction in both the survival and recovery of CCV steelhead and developed, in coordination with Reclamation and DWR, a Reasonable and Prudent Alternative (amended in 2011) with 72 actions that avoided jeopardizing the continued existence of the ESU.

As previously described for Sacramento River winter-run Chinook salmon and CV spring-run Chinook salmon, the proposed action analyzed in this Opinion does not include some of the actions that NMFS relied on in the RPA to avoid jeopardy. Most notably for CCV steelhead, the proposed action does not include certain protective mechanisms for San Joaquin basin steelhead including RPA Action IV.2.1: San Joaquin River flow requirements (I:E ratio) which restricted export rates to a ratio of the inflow of the San Joaquin River as measured at Vernalis during April and May. Reclamations modeling for the proposed action indicated that combined exports would almost double during April and May without the I:E ratio in place and the effects analysis determined that absent other protections, this could put San Joaquin basin steelhead at significant risk. Reclamation also did not carry forward the installation of the Head of Old River Barrier. Buchanan (2019) found that when the Head of Old River Barrier is installed, the probability of total predicted survival from the HOR to Chipps Island was higher than without the barrier under certain flow conditions. This lead to our analysis finding that the proposed action will lead to lower survival of 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 by the South Delta Agricultural Barriers Effects Report (California

Department of Water Resources 2018b) that 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 action could create conditions that would reduce steelhead survival to Chipps Island for the Southern Sierra Nevada Diversity Group, further exacerbating the already diminished status of this diversity group.

During the consultation process, NMFS and Reclamation worked to develop actions that might partially offset the effects to San Joaquin basin steelhead related to not having and I:E ratio or Head of Old River Barrier in plan. Delta Performance Objectives including a Cumulative Loss Threshold and a Single-year Loss Threshold with two time periods (December through March and April through June) that are intended to provide protections for both San Joaquin basin and Sacramento basin CCV steelhead. Reclamation also proposed the CCV steelhead Lifecycle Monitoring Program, in part to help improve CCV steelhead science to can be used to protect San Joaquin Basin steelhead and inform actions such as water operations.

Reclamation did not carry forward the Fish Passage Program, which was expected to reduce the adverse effects related to Shasta operations on listed anadromous fish. Other RPA actions that were intended to avoid jeopardizing CCV steelhead were also not explicitly carried forward into the proposed action. However, NMFS initial sufficiency reviews and preliminary analyses indicated that not including these RPA action was likely to place individuals and species at high risk. Iterative refinement of the proposed action since January 2019 in response to these initial findings (as described in the Introduction) resulted in Reclamation identifying proposing additional protective mechanisms such as the Delta Performance Objective, a $14 million commitment to the Battle Creek Salmon and Steelhead Restoration Project, improving fish passage on Deer Creek, and reducing the risk or straying into the Colusa Basin through improvements to the Knights Landing Outfall Gates, that would address the objectives of the 2009 RPA and additional necessary protections identified from new information available since 2009.

The risk to the CCV steelhead DPS posed by the proposed action is considered in the aggregate context of the effects of the proposed action itself, the species' status, the environmental baseline, cumulative effects, and effects from interrelated and independent actions. Currently the CCV steelhead DPS is at moderate risk of extinction (National Marine Fisheries Service 2016b). However, there is considerable uncertainty with regard to the magnitude of that risk, due in large part to the general lack of information and uncertainty regarding the status of many of its populations. Here, the combined risk to individual populations are evaluated to determine the risk to the DPS as a whole.

As described in the Recovery Plan, watersheds in the four diversity groups were prioritized into three categories (Core 1, Core 2 and Core 3) (Table). Core 1 watersheds possess the known ability or potential to support a viable population. Core 2 populations meet, or have the potential to meet, the biological recovery standard for moderate risk of extinction. Although Core 2 watersheds are lower priority, they remain important because they provide increased life history diversity to the ESU/DPS and are likely to buffer against local catastrophic occurrences that could affect other nearby populations. Considering the distribution of CCV steelhead across several diversity groups, NMFS evaluates risk at both the diversity group level and population priority to assess the proposed action's potential impact on the CCV steelhead DPS overall into context.

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, and in Cow Creek, Battle Creek, and Redding area tributaries. Habitat in some of these areas is highly degraded. Two 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.

Proposed changes to refill operations at Shasta Dam 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. Temperature management tiers, dry year planning, monitoring, and particularly four-year reviews of the Upper Sacramento River Performance Metrics are expected to address uncertainties identified in this opinion, and minimize the impacts of the proposed action on the abundance and productivity of this steelhead 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.

Battle Creek spawning and rearing habitat is expected to improve under the proposed action compared to current conditions due to proposed restoration efforts. The Battle Creek population is a Core 1 population, and therefore benefits to this population are expected to benefit the overall viability of the Northwestern California diversity group.

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 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.

Overall, while still impaired, the Clear Creek population productivity and abundance is expected to be slightly improved over current conditions as a result of 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.

Northern Sierra Nevada

The American River population of CCV steelhead is one of several within this diversity group. 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. Ongoing habitat restoration actions in the American River under the proposed action and new proposed funding of fish passage at Deer Creek are expected to support the abundance and productivity of both populations. Operation of the Nimbus Fish Hatchery Steelhead Program will continue to harm the genetic diversity of this population, although development and implementation of an HGMP will improve the genetic management of steelhead within the hatchery program over current conditions.

Deer Creek, which is expected to only be positively impacted by the proposed action, is the only Core 1 watershed in the Northern Sierra Nevada diversity group. The combined effects of the proposed action on the Deer Creek and American River populations are not expected to reduce the viability of the diversity group overall.

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 still important to maintaining the life history diversity and spatial structure of the diversity group as a whole.

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 provide poor migration conditions for adults and juveniles, consistent with current conditions. Proposed restoration of spawning and rearing habitat in the Stanislaus River will at least partially offset these effects.

Temperature and water quality effects from proposed CWP operations are also expected to continue impacting the survival and growth of incubating eggs and juveniles, consistent with current operations. Operation of south Delta agricultural barriers will likely continue to inhibit populations migrating to and from the San Joaquin River. In addition, the proposed action will continue or increase juvenile entrainment in CVP/SWP pumping projects, and is expected to impede migration for adult and juvenile CCV steelhead from the Sacramento and San Joaquin basins migrating through the Delta.

Taken together, and 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.

Table 139. Central Valley Steelhead Diversity Groups and Watershed Prioritization. Divisions included in the proposed action are bold.

Diversity Group (number of viable populations needed to meet ESU level recovery criteria)	**River or Creek**	**Priority**
Basalt and Porous Lava (2)	**Battle Creek**	Core 1
	Cow Creek	Core 2
	Sacramento River (downstream	Core 2
	Redding Area Tributaries	Core 2
Northwestern California (1)	Putah Creek	Core 2
	Thomes Creek	Core 2
	Cottonwood/Beegum Creek	Core 2
	Clear Creek	Core 1
Northern Sierra Nevada (4)	Mokelumne River	Core 2
	American River	Core 2
	Auburn Ravine	Core 2
	Feather River (downstream from	Core 2
	Yuba River downstream from	Core 2
	Butte Creek	Core 2
	Big Chico	Core 2
	Deer Creek	Core 1
	Mill Creek	Core 1
	Antelope Creek	Core 1
Southern Sierra Nevada (2)	Calaveras River (downstream from	Core 1
	Stanislaus River (downstream from	Core 2
	Tuolumne River (downstream from La	Core 2

Source: modified from (National Marine Fisheries Service 2014b)

Climate Change

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.

11.5.5 Summary of Risk to California Central Valley Steelhead

As described in the Analytical Framework of this Opinion, the risk to the CCV steelhead DPS posed by the proposed action is evaluated in the aggregate context of the species' status, the environmental baseline, cumulative effects, and effects from interrelated and independent actions. Because the DPS is composed of several populations within four diversity groups, the effects of and risks associated with the proposed action must be considered in the context of the distribution of populations across multiple diversity groups. In total, three of six Core 1 populations and three of 15 Core 2 populations are expected to be affected by the CVP. NMFS expects that despite ongoing adverse effects of the Central Valley Project 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 conservation measures and other actions intended to maintain the abundance, productivity, spatial structure, and/or diversity of the DPS in those populations potentially impacted by the proposed action.

NMFS has finalized recovery planning for the CCV steelhead DPS (National Marine Fisheries Service 2014b). Several elements of the proposed action are aligned with or directly implement recovery actions identified in the recovery plan, as described in Section 11.1.7. 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 harvest monitoring and management. Implementation of the proposed action is therefore not creating conditions that would preclude recovery of CCV steelhead in the future.

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 the survival or recovery of the CCV steelhead DPS.

11.6 California Central Valley Steelhead Effects on Critical Habitat

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. 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. The PBFs for CV spring-run Chinook salmon critical habitat include (1) freshwater spawning sites, (2) freshwater migratory corridors, (3) freshwater rearing sites, and (4) estuarine habitat.

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 physical and biological features of available critical habitat is currently highly degraded. CCV 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 physical and biological features 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 physical and biological features have also been degraded within the Sacramento and San Joaquin 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 Deltas (including dredging, agricultural barriers, water exports, vessel traffic, and food web disruption from invasive species) continue to further limit habitat quality.

Ongoing and proposed activities associated with the proposed action affecting the function of essential physical and biological features include:

- operating CVP project dam releases for flood control, temperature and flow management, Delta water quality management, and service contract delivery,
- operating Delta facilities and managing agricultural barriers, withdrawal pumping, and water transfers 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, and
- funding habitat restoration and fish passage improvements.

The effects of these proposed activities on the physical and biological features of designated critical habitat are characterized as those that provide for successful spawning, rearing, and migration below.

11.6.1 Spawning, Incubation, and Emergence

Water temperatures play a significant role in the function of salmonid spawning habitat. However, due to the timing of CCV steelhead spawning and incubation (November through April) the temperature effects of CVP current and proposed operations are largely not expected to impact the function of spawning habitat physical and biological features. The proposed action will likely result in minor decreases in American and Stanislaus River spawning habitat function in the driest years due to increased temperatures at the tail end of spawning (March and April), similar to current conditions. Minimum flows under the proposed action would provide adequate habitat extent and quality for successful spawning, incubation of eggs, fry development and emergence for CCV steelhead. Analyses show proposed reduced fall flows are likely to increase the useable spawning habitat area for CCV steelhead in November when early spawners may be arriving, although otherwise there is slightly reduced weighted usable area for spawning compared to current conditions.

Flows under the proposed action are unlikely to affect the amount of upstream gravel currently supplied by the tributaries, although ongoing dam operations would continue to limit downstream gravel transport. However, flow operations aimed at restoring normative river processes, such as channel maintenance and spring pulse flows, are expected to at least partially offset these effects by mobilizing gravels and increasing the function and extent of spawning and incubation habitat. In Clear Creek proposed pulse and maintenance 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 physical and biological feature function in this reach. In addition to operational measures, the proposed action also includes a number of projects to improve spawning habitat. These include adding spawning gravels to the Sacramento and Stanislaus River systems, funding the Battle Creek Restoration Project, and the SRS Contractors Recovery Program, which will increase the amount of available suitable spawning and incubation habitat compared to current conditions.

11.6.2 Rearing

Dam operations will continue to limit the extent of cold water rearing habitat in downstream reaches of the Sacramento, American, and Stanislaus Rivers once the cold water pool has been exhausted, degrading juvenile rearing habitat in some months and particularly in drier years. This is consistent with current conditions, although temperatures during the summer and early fall are likely to be improved for rearing below CVP dams under the proposed action compared to current operations. The proposed CVP flow releases are expected to largely maintain the same extent of suitable rearing habitat and access available under current conditions, except during January and February when proposed flows may result in less available useable rearing habitat area for outmigrating juveniles. Water temperatures in the lower watershed are expected to continue to be warm and suboptimal for rearing and growth in the summer months. During the proposed fall and winter flows access to riparian juvenile rearing habitat in the upper middle Sacramento River may improve, and floodplain inundation is expected to be the same or greater from December through August, improving the quality of rearing habitat as juvenile are outmigrating. Proposed San Joaquin operations do not allow for overbank flow to maintain floodplain connectivity, and would continue to reduce access to and creation of higher quality rearing habitat compared to current conditions. The proposed action is unlikely to affect contaminant levels or sources in the action area. While CVP operations would continue to limit channel- and habitat-forming processes in the action area, proposed pulse flows and channel maintenance flows would counteract these ongoing effects. In addition, habitat restoration actions in Battle Creek and through the SRS Contractors Recovery Program, in addition to gravel augmentation and rearing habitat restoration in the Stanislaus River, are expected to largely offset these effects.

In the Delta, proposed CVP flow releases to manage for water quality and smelt habitat are likely to maintain or increase the suitability of available rearing habitat. Proposed changes to expand the period of water transfers to October and November may also enhance rearing habitat during these months by increasing flows, which would be expected to improve water quality. Increased flows into the delta may also enhance the forage base compared to current conditions. Modifications of flows to alter nutrient movement into the Delta may also cause a minor benefit in forage base, but also cause minor decreases in water quality. The continued construction of seasonal south Delta agricultural barriers has the potential to degrade rearing habitat function by creating impoundments associated with higher temperatures, lower dissolved oxygen, and increased invasive species abundance during the period of their installation, consistent with current conditions. The restoration of 6,000 acres of tidal habitat is may temporarily degrade rearing habitat during construction by introducing contaminants, reducing water quality, and reducing forage base, but provide a net increase in available suitable rearing habitat shortly (within 1 to 2 years) after construction, and these benefits are expected to last for many years into the future.

11.6.3 Freshwater Migration Corridors

Proposed flows in the Sacramento and San Joaquin Rivers are generally sufficient to maintain access both to and from spawning habitats. During summer months temperatures may exceed thresholds for adult migration, although these temperatures would be slightly lower under the proposed action than current conditions. Proposed Sacramento flows are also expected to be lower in the fall than under current operations, which may reduce the quality of migratory corridors during those months by exposing juveniles and adults to more frequent and warmer unsuitable temperatures and potentially impeding adult migration. The spring pulse flows on the Sacramento, however, will result in beneficial effects to the migratory corridor physical and biological features for juveniles and adults during spring months in years the operation is implemented, as will similar operations on Clear Creek and the American River. In Clear Creek and the Stanislaus River flows and temperature management will also improve migratory habitat conditions for juveniles and adults in fall months compared to current conditions. Ongoing and future actions on Battle Creek will improve the migratory corridor, particularly on the North Fork, with the recent removal of Wildcat Dam and ongoing fish passage improvements associated with fish screens and fish ladders at other dams. Reclamation's commitment to provide funding to improve passage at Deer Creek Irrigation District Dam and fund repairs of the Knights Landing Outfall Gates will also improve the extent and function of physical and biological features of freshwater migration corridors for adults in the action area. Unscreened diversions also impede migration by entraining fish, and while these will continue to degrade the quality of the migratory corridor under the proposed action more diversion screen improvements are expected to be implemented over time. Additionally, the SRS Contractors Recovery Program will result in benefits to adult migrants and rearing and migrating juvenile fish from the construction of fish passage projects.

11.6.4 Estuarine Habitat

In the Delta, increases in flows due to the proposed action would be expected to improve the function of freshwater migratory habitat for juveniles in October and November compared to current conditions by increasing flow velocity in the main channels. However, concomitant export operations at the CVP/SWP pumping plants that reverse flows impair routing and timing for outmigrating juveniles. Flow and olfactory cues may also be altered by the flow of river waters towards the export facilities rather than downstream towards the western Delta as adult CCV steelhead are entering the system to spawn. However, the influence of increased flows should primarily improve habitat corridor function for adults and promote access into the upper rivers from the Delta, particularly into designated critical habitat in the San Joaquin basin. Water releases for management of Delta smelt habitat are expected to provide minor improvements in the migratory corridor flows over current conditions, although operations of control gates for these actions and other studies are expected to cause degradation in the quality of the corridor by impeding migration of juveniles and adults. Continued alterations in flow and the creation of migratory barriers are anticipated from the installation and operation of the south Delta agricultural barriers for both adult and juvenile CCV steelhead. Proposed operation of the Delta Cross Channel is expected to reduce migratory corridor habitat function by delaying juveniles and adults or re-directing them through routes with poorer passage or survival conditions. Proposed periodic closures of Delta Cross Channel gates for fish passage are expected to reduce entrainment of juveniles and delay of adults, at least partially offsetting these effects.

11.6.5 Synthesis of Impacts to Critical Habitat

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 physical and biological features and slow or limit development of these features, with the exception of restoration actions which 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, although 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 as a result of flow management and habitat restoration actions, largely offsetting these continued effects. Proposed operations in the Delta will improve juvenile rearing habitat but may slightly reduce quality of juvenile migratory corridors compared to current conditions. However, proposed changes are expected to improve Delta migratory corridor function for adult CCV steelhead. Funding of fish passage improvements will also improve migratory corridors and provide access to additional spawning and rearing habitat, offsetting effects degrading critical habitat function elsewhere within the action area.

While there is additional critical habitat in several tributaries outside of 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/SWP and improve others. NMFS expects the proposed ongoing operation of the CVP/SWP will result in diminished function of physical and biological features related to spawning, rearing, and migration within designated critical habitat in the action area. The proposed conservation measures, passage improvements, and restoration actions are expected to improve habitat function within the action area such that, on the whole, the function of physical and biological features 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.

11.7 Southern Resident Killer Whale Effects on the Species

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, and climate change. SRKWs would benefit from the recovery of Chinook salmon populations and increased access to prey and protections to reduce the impacts of vessels and sound, as well as reduced exposure to contaminants in prey items and in the marine environment.

At present, the SRKW population has declined to the lowest levels seen in over thirty years. 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).

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. Preliminary analysis of prey remains and fecal samples sampled during the winter and spring in coastal waters indicate that Chinook salmon from the Columbia River, Central Valley, Puget Sound, and Fraser River Chinook salmon comprise over 90 percent of the whales’ coastal Chinook salmon diet during that time period (NWFSC unpublished data). In general, over the past decade, some Chinook salmon stocks within the range of SRKWs have had relatively high abundance (e.g. Washington and Oregon coastal stocks, some Columbia River stocks) compared to the previous decade, whereas other stocks originating in the more northern and southern ends of the whales’ range (e.g. most Fraser stocks, Northern and Central British Columbia stocks, Georgia Strait, Puget Sound, and Central Valley) have declined. Changing ocean conditions driven by climate change may influence ocean survival of Chinook and other Pacific salmon, further affecting the prey available to SRKWs.

On average since the early 1980s, it appears that fall-run CV Chinook salmon constitute about 20 percent of the total catch and escapement of all Chinook salmon populations that are likely encountered by SRKWs from British Columbia to California, although this proportion varies from about 10-30 percent each year depending on varying strengths in run size (Kope and Parken 2011). Winter, spring, and late fall-run CV Chinook salmon have collectively constitute only a small percentage of all Chinook salmon produced in the Central Valley (5-27 percent over the last two decades, (California Department of Fish and Wildlife 2019a)), and therefore represent a minimal additional component of CV Chinook salmon available to SRKWs. In addition, the known distributions of Chinook salmon along the coast suggest that CV Chinook salmon are an increasingly significant prey source as SRKWs move south along the U.S. West Coast during the winter and spring, constituting the majority of fish along some areas of the U.S. West Coast at times (Bellinger et al. 2015; Shelton et al. 2019; Weitkamp 2010). Available fish harvest data and SRKW diet and contaminants analyses suggest that Central Valley Chinook salmon make up a significant portion of the total abundance of Chinook salmon available to SRKW throughout their range in most, if not all, years. When ranked among other Chinook salmon stocks CV Chinook salmon runs were not among the top twelve considered most important to SRKW recovery, although spring, fall, and late-fall run CV Chinook were identified as more important than several Oregon and California coastal stocks and recognized as important potential prey sources during times of SRKW reduced body condition when relatively fewer Chinook salmon are available (National Marine Fisheries Service and Washington Department of Fish and Wildlife 2018).

There are numerous additional factors that are 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. As part of the recent the Pacific Salmon Treaty negotiation, the U.S. agreed to develop a targeted funding initiative to mitigate the effects of harvest and other limiting factors by investing in habitat and hatchery actions to increase prey available for SRKWs (National Marine Fisheries Service 2019b). Recently, NMFS completed consultation on the operation of the Klamath River water project from 2019 to 2024, which included measures to address disease concerns for juvenile Chinook salmon and coho salmon in the Klamath Basin (National Marine Fisheries Service 2019a). The analysis concluded that hundreds or thousands of more adult Chinook salmon from the Klamath River will be available for SRKWs off the coast of California and Oregon during some years over the next decade as a result of measures proposed in the action.

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 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, 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 available information suggests that large changes in overall Chinook prey abundance (i.e., at least a 15 percent overall increase, as estimated by (Lacy et al. 2017)) are necessary in order for SRKW to reach population growth recovery targets.

11.7.1 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, flow management resulting in redd dewatering and juvenile stranding, and loss at the CVP and SWP export facilities. 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 the beneficial measures that were previously described for Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, and CCV steelhead, such as habitat restoration, spawning gravel augmentation, and operations to minimize entrainment. Drought planning actions and intervention measures may provide some resilience during critical years. Many of those actions are expected benefit fall-run Chinook salmon because of the overlap in migration timing and habitat use between this run and ESA-listed salmonids in the action area.

It is likely that SRKW will continue to be exposed to and affected by reductions and limitations in the abundance of Chinook 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 of SRKW in the action area and increased risks of nutritional stress for individual SRKWs, and that all members of K and L pod are expected to be harmed through the increased risk of impaired foraging due to decreased Chinook salmon abundance in the ocean resulting from these effects. However, the magnitude of this adverse effect is expected to be relatively small. Compared to current operations, the proposed action is estimated to result in a decrease of less than one percent in overall abundance of total Chinook salmon available as prey to SRKW, largely due to the decrease 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 of 951 fewer adults escaping to the ocean under the proposed action when compared to current conditions (-0.21 percent reduction), and a range between 9,733 fewer and 12,637 more adult Chinook salmon available as SRKW prey (2.5 and 97.5 percentiles, respectively). Using only the quantified metrics of the effects of the action, and applying them to the 2019 Pacific Fishery Management Council estimated 1,460,800 Chinook in the ocean, the estimated median decrease of 0.21 percent would constitute a 0.05 percent reduction in the total number of Chinook salmon in the Pacific Ocean available as prey for SRKW. We also recognize that the actual prey reduction experienced in waters where Central Valley Chinook salmon are found and at the times of year SRKWs prey on them is likely greater than this general quantitative estimate, although the magnitude of reduction is still expected to be small.

Due to the iterative process of this consultation, a number of further actions were developed to minimize or offset the impacts of the proposed action on ESA-listed salmonids after initial analyses. Changes in the way the proposed action protects Chinook salmon developed after initial analyses were not considered in the quantitative Chinook salmon production analysis described in the preceding paragraph but are qualitatively considered. These additional refinements include Delta Performance Objectives, which although they target Sacramento River winter-run Chinook salmon and CCV steelhead, would also provide protections for fall-run Chinook salmon and CV spring-run Chinook salmon, and would be expected to at least partially offset the quantified effects. Additional measures, including the continued commitment to transport part of the Coleman National Fish Hatcheries production to the vicinity of the Butte City Bridge for release, would reduce in-river losses and be expected to increase the number of fish entering the ocean and becoming available as SRKW prey. Actions to improve passage conditions at the Knights Landing Outfall Gates and the Deer Creek Fish passage project would improve passage for both CV spring-run Chinook salmon and fall-run Chinook salmon, which would be expected to benefit production and abundance for both runs. Other elements, such as the SRS Contractors Sacramento Valley Salmon Recovery Program and the Collaborative Science Partnership will result in continued actions being taken to improve and restore salmon habitat and to improve the science that is applied to salmon protection and recovery. These commitments are expected to bring further capacity to increasing salmon production and abundance.

11.7.2 Summary of Risk to Southern Resident Killer Whales

The proposed action will result in both adverse and beneficial effects that to CV Chinook salmon that can affect their survival and recruitment potential to the ocean. Initial quantitative analyses of SRKW prey found that the proposed action will result in a relatively small decrease in total Chinook salmon available in the ocean compared to current conditions (<1 percent). These analyses may not have captured all potential stressors limiting abundance of CV Chinook salmon, and indicate high variability in potential CV Chinook salmon response to the proposed action, but also did not consider several components of the proposed action developed to minimize or offset the harmful effects of CVP operation on salmonids. These actions either involve restoration or were developed at later stages of consultation, and include habitat and passage improvements, reducing potential for entrainment, improving migration conditions, and HGMP development. All of these proposed action refinements are expected to increase the survival and production of CV Chinook salmon, which are expected to result in a smaller reduction in available prey than what was estimated quantitatively.

We further considered the expected reduction in CV Chinook salmon available as prey under the proposed action in the context of temporal overlap with feeding SRKW. While recognized as important high-value prey sources during the time of year SRKW are in the offshore waters of Oregon, Washington, and California, CV Chinook salmon are only available as prey during that time (i.e., late fall through spring). When compared to other Chinook salmon stocks on the basis of SRKW diet and degree of spatial and temporal overlap, CV Chinook salmon are not considered to be among the most critical prey stocks to SRKW recovery. In addition, not all components of the SRKW DPS are expected to be present in the coastal waters within the action area, as available data suggest the J pod has limited occurrence along the outer coast. When considering effects to the SRKW DPS, we recognize that the anticipated less than one percent reduction in total Chinook salmon available in the ocean is only likely to impact two of the three DPS pods (K and L), and would only impact them during non-summer months.

As described previously, the recent 2012 to 2016 drought had a significant effect on Sacramento River winter-run Chinook salmon and CV spring-run Chinook salmon productivity and abundance. The drought had a similar effect on fall-run Chinook salmon productivity and abundance, which depleted the food supply for SRKW in the ocean. River and ocean conditions have since been much more favorable for salmon survival, as seen by recent improvements in salmon abundance in the Central Valley. Periodic and prolonged droughts are typical in California, but we expect that given the climate change scenarios discussed in this Opinion that 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 provide an increased level of 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.

After considering its current rangewide status, the environmental baseline within the action area, the effects of the proposed action, effects of any interrelated and interdependent actions, 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.

11.8 Southern Green Sturgeon Effects on the Species

The sDPS of North American green sturgeon is listed as threatened under the ESA (71 FR 17757). North American green sturgeon (i.e., both the northern and southern DPSs) range from Baja California to the Bering Sea along the North American continental shelf. During the late summer and early fall, subadults and non-spawning adult green sturgeon aggregate in estuaries along the Pacific coast (Emmett et al. 1991; Moser and Lindley 2007). Israel et al. (2009) found that green sturgeon within the Central Valley of California are sDPS green sturgeon. In addition, acoustic tagging studies show that green sturgeon spawning in the Sacramento River are exclusively from the southern DPS (Lindley et al. 2011). This DPS structure and distribution is corroborated by observations of spawning site fidelity (National Marine Fisheries Service 2018f).

Southern DPS green sturgeon are known to range through the San Francisco Bay estuary, the Delta, and the Sacramento, Feather, and Yuba rivers. Mora et al. (2018) estimated that nine percent of historical sDPS habitat has been blocked by dams. In the Yuba River, sDPS green sturgeon have been documented as far upstream as the barrier to potential spawning habitat at Daguerre Point Dam (Bergman et al. 2011). Similarly, sDPS green sturgeon have been observed at the Fish Barrier Dam on the Feather River. On the Sacramento River, the upstream extent of spawning appears to lie somewhere below Anderson-Cottonwood Irrigation District Dam (river mile 298). It is uncertain if there is suitable spawning habitat in upstream reaches to Keswick Dam; this habitat may be too cold at present, but if passage was restored could allow the spawning distribution to shift upstream in response to climate change effects.

Mora (2016a) demonstrated that sDPS green sturgeon spawning sites are concentrated into very few locations. Just three sites accounted for over 50 percent of the spawning activity in the Sacramento River in 2010-2012. A population or DPS with a high concentration of individuals in just a few spawning sites is vulnerable to increased extinction risk due to catastrophic events.

Current available information indicates that the southern DPS of green sturgeon is composed of a single independent population, which principally spawns in the mainstem Sacramento River, but also opportunistically in the Feather and Yuba Rivers. The concentration of spawning into a very few locations makes the species highly vulnerable to catastrophic events. The apparent extirpation from upstream reaches in the San Joaquin River narrows the range of available habitat, leaving little buffer to these potential impacts.

Diversity, as defined in McElhany et al. (2000), includes traits that are influenced by both genetics and the environment such as ocean distribution patterns, age at maturity, and fecundity. Variation is important for several reasons: it allows a species to utilize a wider array of environments, increases the likelihood that some individuals will survive when environmental conditions change, and allows the species to adapt to changing environmental conditions over the long term. It is unclear whether sDPS green sturgeon display these diversity traits and if there is sufficient diversity to buffer against long term extinction risk. The diversity of sDPS green sturgeon is probably low given current estimate of adult spawners and limited spatial structure in the Central Valley.

The sDPS green sturgeon recovery plan (National Marine Fisheries Service 2018f) describes criteria for determining sDPS green sturgeon population recovery and alleviation of threats. Demographic recovery criteria are population metrics that if achieved demonstrate population recovery and alleviation of threats. Recovery actions for sDPS green sturgeon generally include improving access to spawning habitat in the Sacramento, Feather and Yuba rivers and through the Yolo Bypass; improving water temperature and flow management to support juvenile recruitment; managing water quality to reduce exposure to contaminants that limit growth and survival; reducing poaching and creating operational guidelines for fish screens and water diversions in the Central Valley.

Overall, NMFS considers the risk of extinction to be moderate because, although threats due to habitat alteration are thought to be high and the number of spawning adults is relatively low, the scope of threats and the accuracy of the population abundance estimates are uncertain (National Marine Fisheries Service 2018f). However, the sDPS does not meet the definition of viable 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. Additional information about sDPS green sturgeon will be critical to understanding the management needs for this species, especially with regard to robust abundance estimates and the characteristics and distribution of suitable habitats.

The effects analysis did not identify any high magnitude stressors for sDPS green sturgeon. Major effects to sDPS green sturgeon from the PA include: temperature impacts to eggs and larvae in the Sacramento River, potential routing effects at the Delta Cross Channel, entrainment at Delta Export facilities and the installation of Delta Barriers. Beneficial actions include habitat restoration, the small fish screen program, adjustments to water intakes near Wilkins Slough.

11.8.1 Water temperature management in the upper mainstem Sacramento River

The timing of Summer Cold Water Pool Management is such that it coincides with the peak of egg, larval and juvenile green sturgeon presence in the upper Sacramento River. 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 but conditions vary greatly across the distribution of spawning. In the upstream reaches of spawning habitat water releases from Keswick Dam to achieve temperatures of 53.5°F could reduce the spawning and incubation success while in the more downstream reaches, temperatures could become too warm late in the spawning season.

Ambient water temperature modeled under the proposed action may exceed suitable levels (≥17°C or 62°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). Suitability of downstream spawning areas may be further restricted due to increased water temperatures in critically dry water year types, which may become more frequent under different climate change scenarios.

11.8.2 Delta Cross Channel

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 (2018f)). Operation of the Delta Cross Channel gates may influence survival and condition by providing false migration cues for juvenile and adult sturgeon because 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 outmigration. 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 use more conservative thresholds for closing the Delta Cross Channel gates to reduce juvenile salmonid entrainment risk and these closures may also reduce the likelihood that green sturgeon will be killed or delayed by entrainment into the interior Delta.

11.8.3 Entrainment and Loss at Delta Export Facilities

Similar to the effects on salmon and steelhead, Delta export actions could 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 without the context of an accurate abundance estimate, the effects of South Delta operations to sDPS green sturgeon remain uncertain but NMFS expects that the salmonid loss thresholds associated with Old and Middle River management are expected to reduce the export footprint under the final proposed action compared to the original proposed action and potentially result in reduced effects to sDPS green sturgeon.

11.8.4 South Delta Barriers

Installation of the South Delta barriers can cause delayed migration and increased transit times with potential for increased mortality due to increased exposure to poor water quality and high water temperatures. NMFS is uncertain whether delay at the south Delta agricultural barriers will increase predation on juvenile sDPS green sturgeon or reduce their physiological condition. Based on the low numbers that have been salvaged at south Delta export facilities and other observations, few green sturgeon are likely to encounter the temporary rock weirs in the channels of Old River, Middle River, and Grant Line Canal.

11.8.5 Conservation Measures

As part of the Collaborative Planning action component, Reclamation and DWR propose to continue to work within existing authorities (e.g., Anadromous Fish Screen Program) by providing grants to water users for screening small diversions throughout the Central Valley and in the Bay-Delta. This program could reduce early life stage entrainment of sDPS green sturgeon and increase juvenile recruitment if implemented strategically or on a large scale. Reclamation also proposes adding 15,000 to 40,000 tons of spawning gravel to the Sacramento River and its tributaries per year. Screening small diversions, if implemented strategically and on a large enough scale, could reduce losses of juvenile green sturgeon. Supplementing spawning gravels for salmonids could also enhance habitat for green sturgeon if provided in areas where they overlap. Altered flow was considered a medium to low threat in the recovery plan (National Marine Fisheries Service 2018f). If flow is a migration cue for green sturgeon, altered flows could impact in- or out- migration. The Spring Pulse Flow action during March-early April could enhance in-migration cues. The proposed conservation measures for Delta smelt and salmonids include large-scale habitat restoration efforts in the Delta. NMFS expects that these actions will improve the survival and condition of juvenile green sturgeon by improving ecosystem function in the migration corridor.

11.8.6 Climate Change Considerations

In the Sacramento River, the upstream extent of the spawning range for sDPS green sturgeon lies somewhere below ACID Dam (RM 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.

11.8.7 Summary of Risk to Southern Green Sturgeon

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 DPS as a whole.

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, current 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 into 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 Delta Barriers. Effect related to water exports in the south Delta and salvage records indicate that only low numbers of green sturgeon are likely to be entrained at these facilities.

Temperatures in the upper reach of the Sacramento River below the Anderson Cottonwood Irrigation District Dam are likely to be below the optimal range for green sturgeon incubation and juvenile rearing due to cold water releases from Shasta Reservoir to protect winter-run Chinook salmon. This will reduce the productivity of spawning green sturgeon.

The installation of Delta Barriers could affect the ability of sturgeon to migrate within estuarine habitats. Reclamation’s proposed action will not affect the species’ ability to migrate to upstream spawning habitats. The existence of Shasta, Keswick, and the Anderson Cottonwood Irrigation District 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 and the recent decommissioning of Red Bluff Diversion Dam, 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 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 incubation and 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 action includes measures that may partially offset the medium to low ranked stressors cause by the proposed action. Supplementing spawning gravels for salmonids could also enhance habitat for green sturgeon if provided in areas where they overlap. The small screen program could reduce early life stage entrainment of sDPS green sturgeon and increase juvenile recruitment if implemented strategically or on a large scale. Altered flow was considered a medium to low threat in the recovery plan for sDPS green sturgeon, so we expect the proposed Spring Pulse Flow action component to provide a beneficial effect on adult upstream migration. NMFS has finalized recovery planning for sDPS Green sturgeon (National Marine Fisheries Service 2018f). Several elements of the proposed action are aligned with actions identified in the recovery plan, such as developing flow and temperature targets that support sucessful 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, effects of any interrelated and interdependent actions, 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.

11.9 Southern Green Sturgeon Designated Critical Habitat

Green sturgeon critical habitat was designated on October 9, 2009 (74 FR 52300). In marine waters, designated critical habitat is: areas 60 fathom (110 meters) depth isobath from Monterey Bay to the U.S.-Canada border. In freshwater, designated critical habitat is: the mainstream Sacramento River downstream of Keswick Dam (including the Yolo and Sutter bypasses), the Feather River below Oroville Dam, the Yuba River below Dagueere Point Dam, and the Sacramento-San Joaquin Delta.

As described in Section 6.8, critical habitat for sDPS green sturgeon consists of several physical and biological features occurring in freshwater, riverine, estuarine, and marine habitats that are essential for the conservation of the species. Physical and biological features in freshwater that are related to the proposed action are:

- Substrate type or size suitable for egg deposition and development, including cobble and gravel

- Water flow including magnitude, frequency, duration, seasonality, and rate-of-change
- Water quality including temperature, salinity, oxygen content
- Migratory pathway for safe and timely passage within riverine habitats

Physical and biological features in estuarine habitats that are related to the proposed action are:

- Water flow (in the Delta) to allow adults to orient to the incoming flow and migration upstream to the spawning grounds
- Water quality including temperature, salinity, oxygen content, and other chemical characteristics
- Migratory pathway for safe and timely passage of all life stages between riverine and estuarine habitats

These features are considered necessary for successful spawning, rearing, and migration. Many are currently degraded or impaired, but are considered to have high intrinsic value for the conservation of the species.

Therefore, we have evaluated the effect of the proposed action in terms of its effect on the physical and biological features present in the freshwater and estuarine habitats for rearing juveniles and migrating juveniles, adults, and sub-adults.

Many of the physical and biological features 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.

11.9.1 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 a number of medium ranked stressors including those related to Shasta water temperature management and Delta exports. Beneficial actions include habitat restoration, spring pulse flows, and the reduction of ongoing impairments to the migratory corridor through improved Old and Middle River flow management for salmon.

11.9.1.1 Habitat for Spawning Adults, Incubation of Eggs, and Rearing Larvae and Juveniles

With the proposed action, NMFS does not expect a reduction in the physical and biological feature function of sDPS green sturgeon critical habitat used for spawning of adults and rearing for larvae and juveniles. Specifically, the proposed action is not expected to adversely impact substrate type or size, water flow, and water quality in a way that would significantly impact spawning, incubation, or rearing for this DPS. The proposed action will have periods of higher temperature in lower reaches of spawning habitat, but suitable spawning and incubation temperature is available in accessible upstream areas. Water temperatures from Cold Water Pool

Management in Shasta Reservoir will result in lower than optimum temperatures in a portion of the available spawning and rearing habitat in the Sacramento River and this will decrease the condition of the primary constituent element for water quality, especially in the upper reaches of the Sacramento River near the ACID Dam. Further downstream, the action has a diminished impact on water temperature. The proposed action also does not describe any specific in-water activity that would disturb, contaminate, remove, or otherwise degrade the substrate type or size within the known spawning and freshwater rearing range for sDPS green sturgeon in the Sacramento River.

11.9.1.2 Freshwater and Estuarine Rearing and Migratory Corridors for Juveniles and Adults

The proposed action is expected to result in some degradation to the migratory physical and biological features for juvenile and adult life stages in the lower Sacramento River and Delta. The spring pulse flows in the Sacramento River should improve the function of the freshwater migratory corridor during spring months compared to current conditions. Operations of the CVP and SWP export facilities alters 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. 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. The conservation measures proposed by Reclamation are expected to have a moderately beneficial effect on the migratory corridors of critical habitat. The magnitude of the benefit is low because the measures are expected to largely target salmon.

11.9.2 Synthesis of Impacts to Designated Critical Habitat

Negative effects of the CVP on freshwater migratory pathways that are in the environmental baseline for this consultation (i.e., the existence of Shasta, Keswick, Anderson Cottonwood Irrigation Diversion Fish Barrier, and Daguerre Point 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 and by providing grants for screening small diversions throughout the action area. Although flows have been altered by CVP operations and altered water flow was ranked as a medium to low threat in the recovery plan (National Marine Fisheries Service 2018f), NMFS has not developed flow targets to support green sturgeon spawning and rearing. Barriers in the Yolo Bypass at the Fremont Weir are expected to be improved over the next few years, which should enhance sDPS green sturgeon and improve the quality of the migratory corridor. With the exception of the Spring Pulse Flow action, flows in the Sacramento River will generally be similar to current conditions.

While the physical and biological features 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/SWP and improve others compared to current conditions. NMFS expects the proposed ongoing operation of the CVP/SWP will result in diminished function of physical and biological features related to spawning, rearing, and migration within designated critical habitat in the action area. The proposed conservation measures, passage improvements, and restoration actions are expected to improve habitat function within the action area such that, on the whole, the function of physical and biological features 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.

12 CONCLUSION

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent activities, and 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, CV spring-run Chinook salmon, CCV steelhead, Southern Resident Killer Whales, or the Southern DPS of Green Sturgeon or destroy or adversely modify their designated critical habitat.

13 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 defined 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 defined as an act that "creates 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" (National Marine Fisheries Service 2016e). "Incidental take" is defined 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) 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 programmatic action, 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 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 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 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" (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 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 CVP and SWP is a mixed programmatic action that includes a framework for the development of future actions and 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 U.S. Bureau of Reclamation (2019b) including operations of dams and reservoirs, power plants and pumping facilities, administration of water contracts, implementation of habitat mitigation measures, the development of a Hatchery and Genetics Management Plan[28] for Nimbus Hatchery, fish salvage facilities, conservation actions and research and monitoring activities for which Reclamation provided adequate information regarding the action, the action is reasonably certain to occur, and the action would result in incidental take of listed species. This incidental take statement does not cover framework programmatic action components of the proposed action where information was not sufficient to determine take of listed species. Those actions will be subject to subsequent consultation prior to implementation as appropriate. The incidental take exemptions provided for in this incidental take statement are effective only upon Reclamation's issuance of the Record of Decision.

13.1 Administration of Water Supply Contracts

This consultation addresses the long-term operations of the CVP and SWP as described in the Proposed Action, including the overall impacts of the total 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 non-discretionary deliveries. The volume of water delivered may be reduced from full contract

[28] The primary purpose of a hatchery and Genetics Management Plan is to provide a single, comprehensive source of information regarding anadromous salmonid hatchery programs. This information will be used in ESA processes to assess impacts on listed anadromous fish.

amounts, consistent with the terms of individual contracts. In addition, incidental take from the administration of water transfers is included in CVP and SWP operations for this consultation.

13.2 Stressors Resulting in Incidental Take of Listed Species

The proposed action creates a variety of stressors listed and described in Section 8.1 of the Opinion. Of these stressors, some are expected to result in the incidental take of listed species. Those stressors are:

- **Passage Impediments/Barriers** through operations of the Delta Cross Channel Gates and installation of agricultural barriers. Passage impediments/barrier stressors may include modified routing, modified travel/migration time, and limited habitat.
- **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 gauging stations. For example, the Clear Creek gauge used for the winter-run Chinook salmon spawning compliance point is located directly within the spawning habitat on the Sacramento River. The American River's gauge at Watt Avenue is at the downstream extent of suitable summer rearing habitat for steelhead. On Clear Creek, the available gauging site is at Igo and thus Igo temperatures are used to develop the surrogate. We do not imply that temperature requirements vary based on watershed or river system but only that temperatures conditions may vary based on gauge site.
- **Water flow** within the Sacramento River, 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 diversion intakes, the North Bay Aqueduct intake. Entrainment stressors may include modified routing, modified travel/migration time, and exposure to degraded habitat.

13.3 Amount or Extent of Incidental Take

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 determining when the level of anticipated incidental take has been exceeded, which would require reinitiation of consultation (50 CFR 402.14).

During consultation, as described above in the Opinion, NMFS determined incidental take of endangered winter-run Chinook salmon, threatened CV spring-run Chinook salmon, threatened CCV steelhead, threatened southern distinct population segment (DPS) green sturgeon, and endangered SRKW will occur as a result of the long-term operation of the CVP and SWP.

The proposed action is a totality of many activities that comprise the long-term operation 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 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).

13.3.1 Upper Sacramento River (Shasta and Sacramento) Division

Shasta Dam operations have consequences for the entire system. Operating Shasta Dam (and related facilities) involves temperature, flow, and water quality actions. The *Shasta Cold Water Pool Management Plan* component of the proposed action is the primary mechanism to provide cold water to listed salmonids in this Division. Take of listed species will result from its implementation.

Adherence to the annual *Shasta Cold Water Pool Management Plan* as defined in the proposed action is expected to result in varying levels of take across years, depending on the water management tier applied each year through changes in water temperature and flow. Implementation of the *Shasta Cold Water Pool Management Plan* will result in take of Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, and CCV steelhead.

Ecological surrogates are used for 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 and the 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.

13.3.1.1 Take Anticipated from Water Temperature Effects

As described in the Opinion, water temperatures in the Upper Sacramento River are expected to affect eggs-to-fry[29] survival, impact juvenile growth and survival, and affects 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 temperature-dependent mortality; however, actual temperature-dependent mortality will be a

[29] "eggs-to-fry" includes the intermediate alevin life stage

result of the observed temperatures and their interaction with the present individuals. Although temperatures can be measured, the effect on each individual cannot be measured. Reclamation estimated this effect using a biological model that includes assumed individual responses. The anticipated incidental take from temperature will vary based on the management tier applied to the water year and Shasta cold water pool conditions.

Take of Sacramento River Winter-run Chinook Salmon

At the end of each temperature management season, Reclamation can use the observed temperature data to estimate the temperature-dependent mortality of the egg-to-fry life stage of Sacramento River winter-run Chinook salmon under each tier of the *Shasta Cold Water Pool Management Plan*. Further, the number of fry produced in the Sacramento River each year above Red Bluff Diversion Dam is estimated through ongoing monitoring programs. The estimated number of fry produced will be used to determine the percent of egg-to-fry survival. Egg-to-fry survival can be calculated based on the Red Bluff Diversion Dam estimated fry production divided by the estimated number of female spawners and eggs per female.[30] This information will then be used to estimate the take of Sacramento River winter-run Chinook salmon due to the *Shasta Cold Water Pool Management Plan*.

NMFS anticipates the temperature-dependent egg mortality of Sacramento River winter-run Chinook salmon under the *Shasta Cold Water Pool Management Plan* will be:

- Tier 1 – Average of 6 percent (range from 0.4 to 39 percent) with standard deviation of 9, or
- Tier 2 - Average of 15 percent (range from 1 to 46 percent) with standard deviation of 16, or
- Tier 3 - Average of 34 percent (range from 6 to 77 percent) with standard deviation of 31, or
- Tier 4 – 77 percent or greater

The take of Sacramento River winter-run Chinook salmon will be calculated using a combination of estimated temperature-dependent egg mortality and egg-to-fry survival. Temperature-dependent mortality will be calculated at the end of the incubation period using the (Martin et al. 2017) approach.

Reclamation estimated the egg-to-fry survival of Sacramento River winter-run Chinook salmon under the *Shasta Cold Water Pool Management Plan* will be:

- Tier 1 – Average of 29 percent (range from 15 to 49 percent), or
- Tier 2/3 - Average of 21 percent (range from 15 to 34 percent)

The estimates of temperature-dependent egg mortality and egg-to-fry survival are inclusive for the entire period of time from the construction of the first redd until the final juvenile passes Red Bluff Diversion Dam. The anticipated level of take will be exceeded if there are:

  - Two consecutive years of egg-to-fry survival of less than 15 percent followed by a third year of less than 21 percent based on fry production at Red Bluff Diversion Dam.

[30] This method for calculation could be superseded by another method with mutual agreement with NMFS. The egg-to-fry mortality limits would not change, only the approach to calculate these metrics.

- Two consecutive years where temperature-dependent egg mortality modeled from actual operations exceeds the average plus one standard deviation for the tier determined in the annual temperature management plan and egg-to-fry survival is less than average egg-to-fry survival for the tier. Specifically:
    - *Under a Tier 1 year, take would be exceeded if, in two consecutive years, temperature-dependent mortality exceeds 15 percent (average of 6 percent plus one standard deviation of 9) and egg-to-fry survival is less than 29 percent.*
    - *Under a Tier 2 year, take would be exceeded if, in two consecutive years, temperature-dependent mortality exceeds 31 percent (average of 15 percent plus one standard deviation of 16) and egg-to-fry survival is less than 21 percent.*
    - *Under a Tier 3 year, take would be exceeded if, in two consecutive years, temperature-dependent mortality exceeds 65 percent (average of 34 percent plus one standard deviation of 31) and egg-to-fry survival is less than 21 percent.*

Take of CV Spring-run Chinook Salmon and CCV Steelhead

As discussed in the Opinion, water temperature is an important parameter for the fishs' survival and can result in a failure or death. The organism's survival, growth and reproduction of each organism have critical temperature ranges.

This causal relationship between the fish and water temperature is the basis for using the water temperature as a surrogate for estimating the extent of take for CV spring-run Chinook salmon and CCV steelhead. Balls Ferry is used for spring-run Chinook salmon 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 CV spring-run Chinook salmon under 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.

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.

The conditions described above for determining when the anticipated level of take has been exceeded for Sacramento River winter-run Chinook salmon encompass the range of effects for CV spring-run Chinook salmon and CCV steelhead. Because Sacramento River winter-run Chinook salmon spawn between late-April and mid-August, the trigger that protects winter-run Chinook salmon will also be protective of spawning CV spring-run Chinook salmon. Therefore, the anticipated level of take will be exceeded if a condition for exceedance of take of winter-run Chinook salmon is met.

13.3.1.2 Take Anticipated from Flow Management

Changes in flow can be a stressor in the upper Sacramento River and create benefits. Flow reductions can cause juvenile stranding and redd dewatering while also preserving cold water for use at specific times of the year. Flow increases and pulse flows can benefit juvenile and smolt outmigration. Ramping rates are intended to reduce the magnitude of adverse effects associated with changes in flow. Specifically, decreased flows as a result of fall and winter refill of the Shasta Dam pool will lead to changes in water flow. Reduction in flow will reasonably be expected to result in take of listed species due to stranding, a loss of floodplain inundation, redd dewatering, and side-channel connectivity for Sacramento River winter-run Chinook salmon and CV spring-run Chinook salmon.

The flow regime of a water body is defined by its flow magnitude, timing, duration, frequency, and rate of change. Effects described in the Opinion describe how fish can be injured or killed from certain changes in river flow. 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 an ecological surrogate for the amount or extent of take for salmonids.

The proposed action is reasonably expected to result in the take of juvenile listed salmonids through stranding or desiccated redds throughout the upper Sacramento River from Keswick Dam to Red Bluff Diversion Dam.

Take of Sacramento River 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 one 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 three percent of redds.

The anticipated level of take will be exceeded 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.

13.3.2 Trinity River Division

Reclamation’s operation of Whiskeytown Dam in the Trinity Division in Clear Creek will create stressors of water temperature and flow changes that is reasonably expected to result in take of CV spring-run Chinook salmon and CCV steelhead.

Temperature surrogates are used for this Division because, as described in the 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 cycle, and variation in how individual fish use habitat within Clear Creek.

13.3.2.1 Take Anticipated from Water Temperature Effects

Suboptimal water temperatures in Clear Creek are expected to result in reduced survival and reproductive stress during all life stages for CV spring-run Chinook salmon. Because of the causal relationship between temperature and survival within and between life stages, temperature may 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 gauge. The extent of take is measured by the appropriate life stage habitat between Whiskeytown Dam and the Igo gauge 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 gauge when eggs are in the gravel incubating. This is expected to occur between September 15 and October 31.

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 Lake. Years in which Trinity Lake volume available is in excess of 2.0 million acre feet 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 gauge exceeds 56°F for longer than seven consecutive days or exceeds 57°F for any single day. In years where Trinity Lake volume is less than 2.0 million acre feet but greater than or equal to 1.5 million acre feet 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 seven consecutive days. Poor Trinity Lake storage years, defined as years when end of April volumes are less than 1.5 million acre feet, or times when infrastructure is impaired will require input from the Clear Creek technical team and/or Sacramento River Temperature Task Group 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 an interrelated with the Sacramento River expected take, but will be exceeded if the average daily water temperature exceeds 59°F for longer than seven consecutive days.

The ecological surrogate for the amount or extent of take of CV spring-run Chinook salmon adult life stage is daily average temperature at the Igo gauge June 1 to September 14 based on the water year type of the preceding year. The anticipated level of take will be exceeded if the daily average temperature at the Igo gauge exceeds 60°F from June 1 through September 14 for longer than seven consecutive days or exceeds 61°F for any single day.

13.3.2.2 Take Anticipated from Flow Management

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 fish abundance, diversity, and demographic rates consistently 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 can be used as a surrogate for the amount or extent of take for salmonids.

The ecological surrogate for the amount or extent of take during spring attraction and channel maintenance pulse flows of CV spring-run Chinook salmon and CCV steelhead egg-to-fry life stage is the rearing or incubating habitat exposed to rapid reductions in flow during controlled flow decreases from Whiskeytown Reservoir that may lead to fish stranding or redd dewatering.

The ecological surrogate for the amount or extent of take during base flows for the CV spring-run Chinook salmon and CCV steelhead egg-to-fry life stage is flow lower than 200 cfs for all water year types except critically dry years, which could go below 150 cfs depending on the available water supply.

The anticipated level of take will be exceeded in non-critical years if flows in Clear Creek, as measured at Igo, are lower than 200 cfs between October 1 and May 31 and 150 cfs from June 1 to September 30.

13.3.3 American River Division

Reclamation's proposed action in the American River Division will create stressors of water temperature and flow that is 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 Hatchery Program in the American River. Surrogates may also be used 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, lack of quantification for what optimal water flow are for the species in the American River, the annual variations in the timing of various parts of the species' life cycle, 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.

13.3.3.1 Take Anticipated from Water Temperature Effects

Suboptimal water temperatures in the American River are expected to result in reduced survival during 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.

The CCV steelhead egg-to-fry life stage occurs December through May, and temperatures above 54^{o}F create suboptimal conditions for this life stage. A small proportion of CCV steelhead eggs will still be in redds during May and potentially exposed to water temperatures that will reasonably be expected to result in egg mortality. The extent of take is all redds exposed to temperatures above 54^{o}F in the vicinity of Watt Avenue 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 of the small proportion of eggs or alevins still incubating in the month of May.

CCV steelhead juveniles can survive and grow at water temperatures of 45 to 66^{o}F. Reduced survival is anticipated at temperatures at or above 68^{o}F. The ecological surrogate to define the amount or extent of take of CCV steelhead juvenile life stage is daily average temperature at Watt Avenue May 15 to October 31. The anticipated level of take will be exceeded if temperatures at Watt Avenue exceed 68^{o}F from May 15 to October 31 for more than seven consecutive days unless it is a critical year based on the Sacramento Valley index or a year following one or more critical years.[31] In critical years, and years immediately after a critical year, antipated level of take is exceeded if temperature exceeds 68 ^{o}F at Hazel Avenue.

13.3.3.2 Take Anticipated from Flow Management

Flow fluctuations in the lower American River may result in 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 usuable 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 may 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.

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. Take will be exceeded if flow decreases occur at a rate greater than the ramping rates described in the proposed action, with the exception of flood control or emergency conditions.

The ecological surrogate to define the amount or extent of take of 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). Take will be exceeded if flows are higher than 50,000 cfs in the American River during January to May with the exception of flood control or emergency conditions.

13.3.4 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 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 amount of individuals that are reasonably expected to be taken 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 cycle, and variation in how individual fish use habitat within the Stanislaus River.

[31] In a critical year, or year following critical year, Reclamation will meet with NMFS, FWS, CDFW, and the SWRCB to discuss and determine the best use of the limited cold water pool for that year.

13.3.4.1 Take Anticipated from Water Temperature Effects

Suboptimal water temperatures in the Stanislaus River are reasonably expected to result in reduced survival during egg-to-fry life stage and reduced growth for the juvenile and smolt life stages for CCV steelhead.

The ecological surrogate to define the extent of take in the Stanislaus River is both the magnitude and frequency of suboptimal water temperature in the reach from Goodwin Dam to Orange Blossom Bridge during times when CCV steelhead are present. Because of the causal relationship of flow magnitude, timing, duration, frequency, and rate of change to survival within and between life stages, flow may be used as a surrogate for the amount or extent of take for listed salmonids.

The CCV steelhead egg-to-fry life stage occurs 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 potentially exposed to water temperatures that will be expected to result in egg mortality. The extent of take is all redds exposed to temperatures above 54°F in the vicinity of Orange Blossom Bridge 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.

Steelhead juveniles can survive and grow at water temperatures of 45 to 66°F. Reduced survival is anticipated at temperatures at or above 68°F. The ecological surrogate to define the amount or extent of take of CCV steelhead juvenile life stage is daily average temperature at Orange Blossom Bridge May 15 to October 31. The anticipated level of take will be exceeded if temperatures at Orange Blossom Bridge exceed 68°F between May 15 to October 31 for more than seven consecutive days unless Reclamation and NMFS agree that it is an acceptable exceedance given the hydrologic and meteorological conditions for that year.

13.3.4.2 Take Anticipated from Flow Management

Reclamation proposes to operate New Melones Reservoir (as measured at Goodwin Dam) in accordance with a Stepped Release Plan that varies by hydrologic condition/water year type. The maximum scheduled release rate under the Stepped Release Plan is 3,000 cfs during a spring pulse flow thus higher flow events will only occur during flood control. The Stepped Release Plan 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 low summer flows can delay smolt outmigration. 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 listed salmonids.

The ecological surrogate to define the amount or extent of take of all CCV steelhead life stages in the Stanislaus River is flow. Take will be exceeded if flow releases to the Stanislaus River measured at Goodwin Dam decrease to levels lower than the Stepped Release Plan, or those scheduled by the Stanislaus Watershed Team.

13.3.5 Delta Division

The Delta Division includes multiple proposed action components that is reasonably expected to result in take of Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead and southern DPS 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.

13.3.5.1 Agricultural Barriers

Take is expected during the installation of the three temporary agricultural barriers and the barriers' subsequent operations. 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 installation date, removal date, and operation of the temporary barriers. The installation, removal, and operation of the barriers has a causal link to take because it defines the effect to the habitat used by all listed species, In addition, they cause potential changes in fish behavior and survival. The alteration in the functioning of the channel habitat may cause 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:

1 The operation of the barriers occurs earlier than May 1, or if the barriers are not removed by November 30 of each year.
2 If water temperatures are below 71.6°F (22°C) at Mossdale, and fish passage is precluded.
3 By September 15 of each year, a notch has not been cut in the weir of Old River at Tracy and Middle River barriers, and the appropriate number of flashboards have not been removed at Grant Line Canal barrier to facilitate upstream movement of Chinook salmon.

13.3.5.2 Delta Cross Channel Gates

ESA-listed fish may be taken 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 increased 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 will open or 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 normal rounding rule to the tenth[32]. 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 within and between life stages, frequency and duration of opening may be used as a surrogate for the amount or extent of

[32] Normal Rounds digits 1,2,3, and 4 down. Rounds digits 5,6,7,8, and 9 up.

take for listed salmonids. The anticipated level of take will be exceeded if the number or duration of openings exceed those described in the proposed action.

13.3.5.3 CVP and SWP Pumping Facilities

The operation of CVP and SWP pumping facilities is reasonably expected to result in the take of listed fish in the forms of injury, harm, or mortality. Diversions result in altered routes and entrainment that is expected to result in increased migration time, exposure to predation, salvage, and impingement of fish. Routine periodic biological sampling is done during salvage operations at pumping facilities to monitor for the presence of listed fish. The individual listed fish in the periodic sample represent other individuals of each listed species that are entrained or their migration route has been altered by a CVP or SWP diversion. We establish an anticipated level of the number of listed fish in the salvage sample that, once reached, requires operational changes at the pumping facilities to avoid exceeding the anticipated level of take (Table 140).

At year five post-implementation of this Opinion, Reclamation and NMFS shall revisit the anticipated level of incidental take with new science and an expected new population-level index to determine the appropriate scalable take level.

Table 140. Maximum anticipated annual incidental take levels of listed species at the Bay-Delta pumping facilities.

Species	Measurement	Maximum Annual Quantity
Winter-run Chinook salmon	Loss of natural winter-run	1.3% of the juvenile production estimate (JPE) on a three-year rolling average or 2.0% of the JPE in any single year.
Winter-run Chinook salmon	Loss of hatchery winter-run - Sacramento River	0.8% of the estimated hatchery JPE (fish surviving to the Delta) from LNSFH released into the upper Sacramento River on a three-year rolling average or 1.0% of the JPE in any single year.
Winter-run Chinook salmon	Loss of hatchery winter-run - Battle Creek	0.8% of the estimated hatchery JPE (fish surviving to the Delta) from LNSFH released into Battle Creek on a three-year rolling average or 1.0% of the JPE in any single year.
CV Spring-run Chinook salmon - yearlings	Loss of late fall-run Chinook salmon from CNFH	1% of the estimated number of late fall-run Chinook salmon released from CNFH in each surrogate release group released into Battle Creek.
CCV Steelhead (naturally-produced)	Loss of CCV steelhead December 1 - March 31	1,571 juveniles as a three-year rolling average or total loss of 2,760 in any single year
CCV Steelhead (naturally-produced)	Loss of CCV steelhead April - June 15	1,725 juveniles as a three-year rolling average or total loss of 3,040 in any single year
Southern DPS Green Sturgeon	Salvage of sDPS Green Sturgeon	74 juveniles

13.3.5.4 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 winter-run Chinook salmon, CV spring-run Chinook salmon and CCV steelhea, will be the maximum permitted diversion rate of 350 cfs. If diversion of water through the Rock Slough Diversion intake exceeds this rate, then the anticipated level of take will have been exceeded.

13.3.5.5 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 Suisun Marsh Salinity Control Gates 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 Suisun Marsh Salinity Control Gates potentially alters fish behavior, including migratory delays for both adult upstream migrants and smolt outmigrants. Listed fish may also be exposed to increased predation through increased exposure time in the channel of Montezuma Slough adjacent to the radial gates. 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 Suisun Marsh Salinity Control Gates 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 potential changes in fish behavior and exposure to predation. The ecological surrogate for take of Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon is the operation of the Suisun Marsh Salinity Control Gates pursuant to the proposed action. If the Suisun Marsh Salinity Control Gates are operated in a manner not consistent with the proposed action, then the anticipated level of take of listed salmonids and sDPS green sturgeon will have been exceeded.

13.3.5.6 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 winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon will be the maximum diversion rate of 175 cfs. If the Barker Slough Pumping Plant and the North Bay Aqueduct intakes are operated in a manner not consistent with the proposed action, then the anticipated level of take of listed salmonids and sDPS green sturgeon will have been exceeded.

13.3.5.7 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.

The removal of sediment that accumulates in front of the screens and within the pumping bays of the Barker Slough Pumping Plant is reasonably expected to result in entrainment during the use of a hydraulic dredge. If dredging is used to remove sediment buildup on the aprons in front of the fish screens, there is the potential for fish entrainment into a hydraulic dredge while the sediment is removed. The relatively small volume of sediment removed allows for salmonids and green sturgeon to be observed and counted during the dredging operation. 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 Sacramento River 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 141).

Table 141. Incidental Take for Sediment Removal and Aquatic Weed Control at Barker Slough.

Action	Cumulative Take of Juvenile Salmonids (WR, SH, SR,) Individuals/year	Cumulative Take of Juvenile sDPS Green Sturgeon/ year
Sediment Removal	5	2
Weed Removal	5	2

13.3.5.8 Clifton Court Predator Management: Predator Reduction Electrofishing Study

Take of ESA-listed fish are reasonably expected to occur in the forms of harassment, capture, trap, handling, injury, harm, or death during the predator reduction electrofishing study and predatory fish relocation study. Based on results of previous years of studies, the anticipated level of take will be exceeded if the two-year take for the combined predator reduction electrofishing study and the predatory fish relocation study within Clifton Court Forebay is higher than described in Table 142.

Table 142. Cumulative incidental take for predator fish reduction electrofishing and predatory fish relocation studies.

Species	Two-year Non-lethal Incidental Take (juveniles and adults)	Lethal Incidental Take (juveniles)
Southern DPS Green Sturgeon	20	3
California Central Valley steelhead (unclipped)	50	5
Central Valley spring-run Chinook salmon	50	5
Sacramento River winter-run Chinook salmon	50	5

13.3.6 Take of Southern Resident Killer Whale

NMFS anticipates the proposed action will result in incidental take in the form of harm to SRKW individuals in the K and L pods 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 Chinook salmon populations coextensive to the effects analysis described in *Southern Resident Killer Whale Effects Analysis* and *Integration and Synthesis for Southern Resident Killer Whales*, and the measures of surrogates used for the Delta Cross Channel Gates and for CVP and SWP Pumping Facilities. These surrogates are used because they represent life stages of Chinook salmon and steelhead that are most affected and measurable prior to ocean entry. We believe that CCV steelhead surrogates are a reasonable surrogate for SRKWs because steelhead are present at the Delta Cross Channel and the export facilities during periods of the year when CV spring-run Chinook salmon and fall-run Chinook salmon are also present in the Delta and therefore actions that result in adverse effects or protections for CCV steelhead would result in adverse effects or protections for CV spring-run Chinook salmon and fall-run Chinook salmon. Exceedance of take related to these surrogates would be viewed as an exceedance of the anticipated take of Southern Residents as well.

13.3.7 Effect of the Take

In the biological 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.

13.4 Reasonable and Prudent Measures

"Reasonable and prudent measures" (RPMs) are nondiscretionary measures that are necessary or appropriate to minimize the impact of the amount or extent of incidental take (50 CFR 402.02). NMFS believes the following reasonable and prudent measures are necessary and appropriate to minimize take of 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 Trinity Division/Clear Creek 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 Eastside 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 Southern Resident killer whales during operations.

7. Reclamation and DWR shall monitor and report the amount and extent of take to NMFS.

8. Reclamation and DWR shall minimize the impact of the amount or extent of incidental take of listed species associated by implementation of the proposed action by supporting the implementation of actions through the Collaborative Planning action component.

9. Reclamation and DWR shall implement a program to accelerate steelhead research and monitoring to develop juvenile population abundance estimates and consider using these estimates to develop revised incidental take levels and scale juvenile steelhead salvage and loss to a population abundance estimate.

10. Within five years, Reclamation and DWR shall assess a potential Delta Performance Objective for young-of-year CV spring-run Chinook salmon.

13.5 Terms and Conditions

The terms and conditions described below are non-discretionary, and Reclamation and DWR must comply with them in order to implement the RPMs (50 CFR 402.14). 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 comply or ensure compliance by their contractor(s) with the following terms and conditions, which implement the reasonable and prudent measures described above.

For the purposes of this incidental take statement, NMFS “coordination” with Reclamation and DWR does not mean NMFS concurrence with an action is required under the specified coordination, but rather that NMFS is afforded the opportunity to provide scientific or technical recommendations for Reclamation’s consideration on issues for which NMFS has scientific or technical expertise, such as biological issues. Such recommendations would not require changes to Reclamation’s Proposed Action, or water and power resources operations and facilities operations pursuant to the Proposed Action.

RPM 1: Reclamation shall minimize the impact of the amount or extent of incidental take of listed species during operations of the Shasta Division.

a. In coordination with NMFS and the Sacramento River Temperature Task Group, Reclamation shall consider technical assistance from NMFS regarding the development of annual temperature management plans, regardless of Shasta storage or tiered temperature management stratum. Reclamation shall submit the final temperature management plan to NMFS by May 20 of each year, as reporting under the opinion. NMFS does not expect Reclamation to seek NMFS concurrence on the plan.

b. Reclamation shall not implement the Spring Pulse Flow if the release would cause Reclamation to drop into a lower Tier of the Shasta summer temperature management.

c. Consistent with the final proposed action, Reclamation shall develop a stratification model for Shasta Reservoir and evaluate this model for implementation as part of the development of annual temperature management plans. The initial stratification model shall be available for pilot application and evaluation no later than January 1, 2022, unless NMFS and Reclamation agree to extend the date. At the end of the three-year period starting once the stratification model is available, Reclamation and NMFS shall submit the model to the four Year Review Panel for advice on the model's accuracy and utility as a forecasting tool, and Reclamation will decide whether implementation is appropriate.

d. By February of each year, Reclamation shall provide a hindcast report of temperature-dependent mortality for winter-run Chinook salmon based on realized temperature management. The report shall include:

    - Performance trends to date, observed range of temperature dependent mortality within Tiers, and range of egg-to-fry survival within Tiers,
    - Whether convening an independent panel is appropriate based on performance trends to date, and
    - Response to previous independent panel reviews and/or identification of how comments from previous independent panel(s) are being addressed.

e. In February of each year Reclamation shall create and post a projection of water operations, as described in Appendix G of the biological assessment.

f. Reclamation shall work with NMFS, FWS, and CDFW to complete a Battle Creek Acceleration Plan by December 31, 2020. The plan shall address the Battle Creek Salmon and Steelhead Restoration Program and the Battle Creek Winter-run Chinook Salmon Reintroduction Plan, and work with FWS to identify Livingston Stone National Fish facility improvements necessary to support the Battle Creek Winter-run Chinook Salmon Reintroduction Plan.

g. In order to minimize project related impacts to fish growth and survival on the lower Sacramento River, Reclamation shall complete construction of the Fremont Weir component of the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project by 2022.

RPM 2: Reclamation shall minimize the impact of the amount or extent of incidental take of listed species during operations in Trinity Division/Clear Creek at Whiskeytown Dam.

a. To minimize incidental take under 60°F daily average water temperature criteria for 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, consistent with the proposed action and in consideration of Shasta Cold Pool Management:
   i. Continue maintenance of temperature control curtains (Oak Bottom and Spring Creek) in Whiskeytown Reservoir.
   ii. Through coordination with the Clear Creek Technical Team, 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. In critical years, Reclamation shall coordinate with NMFS through Clear Creek Technical Team and/or the Sacramento River Temperature Task Group on the timing, frequency, duration and magnitude of flows below 150 cfs.

b. Reclamation shall ensure that the proposed temperature modeling platform for the Sacramento River will consider Clear Creek system, including Whiskeytown Reservoir, to enable better temperature forecasting and planning in Clear Creek. Reclamation shall undertake a study to collect and analyze temperature data in Whiskeytown Reservoir and Clear Creek to determine the magnitude and potential impact on temperatures from power peaking and flat loading of hydropower production. The data collected shall be analyzed and shared with NMFS and considered for implementation in the temperature model. This modeling effort may be a separate process or combined with the Sacramento River model effort referenced above in RPM 1(c).

c. 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.

d. 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:
   i. Coordinate flow release schedules with NMFS, FWS, and CDFW via Clear Creek Technical Team or a comparable inter-agency fish monitoring group.

RPM 3: Reclamation shall minimize the impact of the amount or extent of incidental take of listed species during operations of the American Division.

a. Seasonal operational decisions that affect water temperature and river flows shall be coordinated through the American River Group.

RPM 4: Reclamation shall minimize the impact of the amount or extent of incidental take of listed species during operations of the Eastside Division.

a. The shift in compliance location for dissolved oxygen from Ripon to Orange Blossom Bridge from June 1 to September 30 shall not go into effect until NMFS confirms that Reclamation has satisfied both of the following conditions:

   i. Provide confirmation that a dissolved oxygen gauge has been installed, and

   ii. Consistently providing accurate dissolved oxygen data at Orange Blossom Bridge.

b. Reclamation shall complete the Final Temperature Management Study by December 31, 2025.

c. Reclamation shall provide to NMFS an annual water temperature data set and will provide summary statistics.

d. 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.

RPM 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.

a. Consistent with the additional Delta measures on habitat restoration in the final proposed action, Reclamation shall develop and implement a predator management experiment to reduce the mortality of emigrating juvenile salmonids at "hot spots" in the Bay-Delta.

b. Reclamation and DWR shall monitor the salvage and loss of winter-run Chinook salmon, CV spring-run Chinook salmon, fall-run Chinook salmon, 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 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 the 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, 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, 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 coded wire tag samples from adipose fin-clipped juvenile winter-run Chinook salmon, CV spring-run Chinook salmon, and CCV steelhead 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) Reclamation and DWR shall develop and submit for review and concurrence by NMFS a plan for tissue and whole fish or head processing and storage by December 31, 2020.

c. Reclamation and DWR shall minimize incidental take through the application of best management practices at the fish salvage facilities by developing coordinated protocols within 18 months of the effective date of this Opinion for the following three topics. Be the effective date of the Opinion, Reclamation and DWR shall provide the protocols currently being used.

i. Protocols for fish sampling and handling (from salvage through release), including a description of training procedures and the process for quality assurance and quality control of data.

ii. Protocols for daily estimation of salvage or loss for each ESA-listed anadromous fish that include relevant calculations and identify the data and information sources necessary to perform the relevant calculations used to estimate fish salvage or loss. Each facility shall include in their protocol a process to provide to NMFS, FWS, CDFW, DWR, and Reclamation staff the relevant data and information necessary to calculate fish salvage or loss. The protocol should specify whether and how pumping will be restricted during any salvage disruption, and whether and how salvage disruptions will be reflected in the estimation of salvage or loss. The protocol should include procedures used to implement the single year and cumulative loss thresholds for Delta operations.

iii. Procedures for reporting salvage and loss for each ESA-listed anadromous fish (or relevant surrogate), including a description of the general content, frequency, and distribution of reports. Salvage and loss shall be reported daily (excepting weekends and holidays) from October 1 through June 30 and DWR and Reclamation shall submit to NMFS an annual report summarizing salvage and loss over the previous water year no later than December 31 of each year.

d. Reclamation shall incorporate the following terms and conditions 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, Reclamation and DWR shall follow normal rounding rule to the tenth. The catch indices shall be 3.0 fish per day and 5.0 fish per day.

e. DWR shall incorporate the following terms and conditions related to North Bay Aquaduct/Barker Slough Pumping Plant operations:
   i. Cleaning of sediment from in front of the fish screens shall occur during the summer in-water work window of July 1 through October 31 or if ambient water temperature is greater than 77^{o}F.
   ii. Observers shall be present during sediment cleaning to look for entrained fish in the dredge material discharge as it is pumped into the dredge spoils pit. Any observed fish shall be collected and identified to species. If the species is a salmonid, total body length shall be measured and assigned to race by length at date using the Delta model. Tissue samples shall be collected all natural origin salmonids, and coded-wire tag (CWT) samples from adipose fin-clipped juvenile winter-run Chinook salmon, CV spring-run Chinook salmon, and CCV steelhead, for genetic analysis or tag removal/reading pursuant to appropriate sampling protocols.
   iii. All observed sDPS green sturgeon shall be collected. Any living specimens shall be resuscitated if possible, and released away from the Barker Slough Pumping Plant facilities. All dead specimens shall be retained, frozen, and NMFS notified for final disposition.
   iv. Cleaning of aquatic weeds from in front of the fish screens shall occur during the in-water work window of July 1 through October 31 or when ambient water temperatures are greater than 25^{o}C.
   v. Observers shall look for any salmonids or sDPS green sturgeon entangled in the weed mass as it is placed in the trucks and as it is dumped in the disposal site area. Any observed fish shall be collected and identified to species. If it is a salmonid, total body length shall be measured and assigned to race by length at date using the Delta model. All observed sDPS green sturgeon shall be collected. Any living specimens shall be resuscitated if possible, and released away from the Barker Slough Pumping Plant facilities. All dead specimens shall be retained and NMFS notified for final disposition.
   vi. An annual report shall be sent to 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.

f. DWR shall incorporate the following terms and conditions related to the Predator Relocation Electrofishing Study/Predatory Fish Relocation Study:
   i. The initial "run" of Chinook salmon shall be determined based on length at date criteria if the fish is actually captured and handled prior to release.

ii. Information shall be collected, to the extent possible, regarding whether the fish have an intact adipose fin or not, and any external signs of sutures or an incision, indicating that it is a special study fish (acoustic tags).
iii. For those natural Chinook salmon captured, tissue samples shall be taken for DNA analysis and archived with CDFW.
iv. All salmonids and sDPS green sturgeon shall be immediately processed and returned to Clifton Court Forebay in good health as quickly as possible.
v. If salmonids are observed in the electric field of the electrofishing boats, but are not captured, field crews shall note the approximate size and whether there is an adipose fin or not, if possible.
vi. When salmonids or sDPS green sturgeon are observed in the electric field, electrofishing shall stop in that area, and the boat shall move to another area of the Clifton Court Forebay at least 400 yards away from the previous site, and DWR project managers shall be notified immediately.

g. DWR shall incorporate the following terms and conditions related to the Aquatic Weed Control Program in Clifton Court Forebay:
  i. DWR shall provide notification of intent to conduct aquatic weed removal activities to NMFS at least two weeks prior to starting, including the types of herbicides intended to be used for that application and the areas that will be treated.
  ii. DWR shall send copies of the water quality monitoring results for the concentration of herbicides in the Clifton Court Forebay following treatment to NMFS within 10 business days of DWR's receipt of the results.
  iii. 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.

h. DWR shall incorporate the following terms and conditions related to South Delta Agricultural Barriers:
  i. DWR shall send notice of intent to construct the barriers to NMFS at least 14 days prior to start of construction. This information shall include anticipated start dates and completion dates for each of the barriers. In the fall, DWR shall provide NMFS with the anticipated schedule for removal of the barriers, and notification when the removal has been completed.
  ii. 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.

i. Reclamation and DWR shall coordinate with NMFS through the Sacramento River Temperature Task Group temperature planning processes and the coordination group for the Delta Smelt Summer-Fall Habitat action regarding approaches to for using storage releases for the Delta Smelt Summer-Fall Habitat action.

RPM 6: Reclamation shall minimize the impact of the amount or extent of incidental take of Southern Resident killer whales during operations.

a. Reclamation shall continue to support the FWS' study of alternative release sites for Coleman National Fish Hatchery produced fall-run Chinook salmon for the next two years to determine if trucking to an alternative release site can increase juvenile survival to the ocean and adult returns to the Sacramento River.

RPM 7: Reclamation and DWR shall monitor and report the amount and extent of incidental take described in Section 2.1 as necessary to implement this Opinion.

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. 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 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; checking for acoustic tags which furthers minimizes take of listed fish, unless not practicable.

RPM 8: Reclamation and DWR shall minimize the impact of the amount or extent of incidental take of listed species associated of implementation of the proposed action by supporting the implementation of actions through the Collaborative Planning action component.

a. Reclamation and DWR shall convene an annual Director's meeting through CSAMP to review the past year's collaborative planning actions and coordinate on future year priorities.

RPM 9: Reclamation and DWR shall implement a program to accelerate steelhead research and monitoring to develop juvenile population abundance estimates and consider using these estimates to develop revised incidental take levels and scale juvenile steelhead salvage and loss to a population abundance estimate.

b. <u>Phase 1 (Beginning October 2020):</u>
   i. Consistent with the proposed action, implement steelhead research and monitoring actions to develop a juvenile production estimate for steelhead-producing tributaries with CVP or SWP facilities.
   ii. Reclamation and DWR will coordinate with NMFS, CDFW, FWS, CSAMP, and others as necessary, regarding juvenile production estimates on non-project tributaries.
   iii. Develop an initial report for consideration of the four-year panel review (2024).
   iv. Prepare summary report of population abundance estimates by September 2025.

b. <u>Phase 2 (Beginning September 2025):</u>

i. Consider and revise incidental take estimate based on updated population status and survival.
ii. Consistent with the proposed actions, implement steelhead research and monitoring actions as effectiveness monitoring of Proposed Action operations and conservation measures.
iii. Develop summary report for consideration of the second four-year review (2028).

RPM 10: Within 5 years, Reclamation and DWR shall assess a potential Delta Performance Objective for young-of-year CV spring-run Chinook salmon

a. Reclamation and DWR shall conduct a set of CWT-tagged juvenile Chinook salmon releases during winter and spring to provide increased information on presence and loss of Sacramento basin natural and hatchery spring run Chinook salmon through recovery in fishery and fish collection facility monitoring surveys.
b. Develop an initial report for consideration of the four-year panel review (2024).
c. Prepare summary report of findings by September 2025.
d. Consider and revise incidental take estimate, based on new information.

13.6 Conservation Recommendations

Section 7(a)(1) of the ESA directs Federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of the threatened and endangered species. Specifically, conservation recommendations are suggestions regarding discretionary measures to minimize or avoid adverse effects of a proposed action on listed species or critical habitat or regarding the development of information (50 CFR 402.02).

Reclamation and DWR should use the recovery plans for Central Valley Salmonids (National Marine Fisheries Service 2014b) and sDPS Green Sturgeon (National Marine Fisheries Service 2018f) to guide the selection of projects and efforts to support the survival of these species. Reclamation, in coordination with the Clear Creek Technical Team, should identify and implement projects to restore the creek channel to one that is more responsive to the decreased magnitude high flow releases. Examples: lowering floodplains, removal of encroached riparian vegetation, creation of braided channels, all which improve would improve connectivity with the lower magnitude flows, increasing and improving the amount and quality of spawning and rearing habitat.

- Support the enhancement of floodplain habitat in the Sutter Bypass.
- Provide fish passage and floodplain habitat at Tisdale Weir within five years and Colusa Weir within ten years.
- Inventory historic oxbows and design fish passage and floodplain projects within five years and implement projects within ten years.
- Support fish passage improvements on anadromous fish-bearing tributaries of the Central Valley.

Reclamation and DWR should support the following Lower San Joaquin River Habitat Projects consistent with the Collaborative Planning Action.

i. Restoration of floodplain access and San Luis National Wildlife Refuge
ii. Sturgeon Bend Floodplain Restoration
iii. Durham Ferry State Recreation Area floodplain restoration

Reclamation and DWR should support the following physical and non-physical barrier projects.

ii. Non-physical exclusion barrier at Georgiana Slough consistent with DWR's prior pilot study results.
iii. DWR Salmon Protection and Technology Study at Steamboat and Sutter Sloughs.

Pursuant to the FWS June 19, 2019 Letter providing an update on four efforts that the FWS has been engaged in regarding Coleman and Livingston Stone National Fish Hatcheries and their contribution to the management and restoration of Chinook salmon in the Sacramento River and Battle Creek (Appendix G), Reclamation should work with FWS to:

iv. Secure an emergency/alternate water supply when Shasta and Keswick reservoirs reach elevations below the current penstock, or acquire (either purchase or rent) water chillers to ensure that adequate water temperatures are provided during critical winter-run Chinook salmon life stages (e.g., adult holding, egg incubation, and juvenile rearing).
v. Support the findings of a multi-agency teamed that concluded the need to expand by 8 to 10 circular tanks to raise an additional 350,000 fish if the hatchery were to engage in the same drought operations they did in the recent drought. Increasing the capacity of Livingston Stone National Fish Hatchery would require expanding to the west side of the hatchery road, additional piping to that side of the property, and additional water.
vi. Coordinate with FWS to evaluate the need for modifications or improvements to Keswick Dam Fish Trap and Elevator, or operational adjustments to reduce the likelihood of injure or death to adult fish entering or attempting to enter the trap.
vii. Coordinate with FWS to investigate the feasibility of installing an alternative winter-run fish collection facility on the south side of the Sacramento River at the Anderson-Cottonwood Irrigation District fish ladder. The study should begin in in January 2020. If the results of the investigation determine that a collection facility would be technically and economically feasible, Reclamation should install such a facility within two years of the recommendation.
viii. Coordinate with the FWS on the need to install a drum screen to remove solids from the hatcheries effluent. The purpose of the drum screen would be to provide more flexibility to use medicated feed to prevent disease.
ix. Support the construction of a fish sorting facility at the Coleman National Fish Hatchery

Science and Monitoring

b. Support science actions such as marking and tagging/survival studies for Battle Creek Reintroduction, spring pulse flow actions and for studying alternative release strategies for Coleman National Fish Hatchery fall-run.
c. Support science, model development and monitoring; experimental design (with validation monitoring) for spring pulse flows
d. Reclamation and DWR should update and recalibrate models to use recent data to strengthen their ongoing application base for the purpose of minimizing the effect of take. Models that would benefit from recalibration include:
    i. Loss-density method or other methods recommended by CSAMP
    ii. Delta Passage Model
    iii. IOS model
    iv. SWFSC Central Valley Winter-Run Chinook Life Cycle Model
e. In order to reduce uncertainties regarding the mechanisms and extent of take in the form of juvenile salmonid behavioral modifications to hydrodynamic changes in the south Delta that are associated with water operations, Reclamation and DWR should,:
    i. Implement the recommendations of the CAMT 2017 workplan for salmonids (Salmonid Scoping Team 2017a; Salmonid Scoping Team 2017b). As part of this workplan, Reclamation and DWR should fund continued development of enhanced particle tracking modeling that is sensitive to realistic changes in south Delta operations, analyze existing data, and conduct experiments to assist in model development.
    ii. Develop an adaptive management approach with a sound experimental design to test key alternative hypotheses (e.g., exports are important in addition to inflow in some circumstances in influencing juvenile salmon behavior, etc.). This experimental approach should build on lessons learned from VAMP, the six-year steelhead study, and the CSAMP/CAMT gap analysis report and recent Delta salmonid research workshop (that occurred on May 22, 2018). The study design would likely need to test both more restrictive and less restrictive approaches given low survivals in the South Delta. This experimental operational approach could be paired with habitat restoration and or predator management actions/studies in the Delta and on the main stem San Joaquin River.
f. Reclamation and DWR should pilot some alternative techniques to quantify incidental take of listed anadromous salmonid species at the Federal and State export facilities.
g. Reclamation and DWR should make (or continue to make) all monitoring data collected under implementation of this Opinion publicly available in order to facilitate integration with concurrent ecological monitoring efforts related to anadromous fish in the California Central Valley.

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